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BASIC PROCEDURES FOR SMALL BALLOON FLIGHTS 1976



OFFICE OF NAVAL RESEARCH
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Arlington, Virginia
22217
(Code 465)

FOREWORD

"Basic Procedures for Small Balloon Flights" has been provided by the Office of Naval Research as a basic reference for experimentors who are initially contemplating the use of small hand-launched balloons for high altitude scientific research. The project of gathering the material presented here was originally initiated under the auspices of the Scientific Ballooning Standards Committee who recognized the need for improved communications and practices within the industry and throughout the scientific community as a whole. The manual is not the result of any one individual or organization; rather, it is a compilation of the contributions of many. Although the contributors are too numerous to acknowledge individually, special recognition is warranted for the efforts of Mr. J. Smalley, National Center for Atmospheric Research, who functioned as the project editor, and to Messers. W. F. Cross and M. O. Evanick, Field Representatives of the Office of Naval Research, who spent many hours collecting and preparing the contributed materials for publication.

This discussion of balloons, associated hardware, launch procedures, flight, communications and safety precautions is designed to enable the scientific investigator to safely and successfully fly payloads of up to forty kilograms in weight. It is strongly recommended, however, that one contemplating scientific ballooning for the first time should obtain professional assistance. The SBA, more fully described below, would be a good place to seek such assistance. Also, the reader should carefully note the few inset "Cautions" and "Warnings" in the text. Failure to observe "Cautions" could result in a hazard to the success of the mission while failure to heed a "Warning" may result in severe damage or serious injury.

A word should be said here concerning the Scientific Ballooning Association, a recently formed, incorporated, non-profit organization dedicated to the advancement of the art and science of ballooning. Through the process of evolution, the SBA seeks to expand the work and objectives of its predecessor, the Scientific Ballooning Standards Committee, by providing an open forum for the diverse group of individuals and organizational entities interested in some aspect of scientific ballooning. The specific Charter of SBA is to encourage and promote exploitation and expansion of the unique capabilities of balloons as cost effective vehicles for research, development and operational applications.

Anticipating that the SBA will assume the responsibility for maintaining the currency of this manual, it is being distributed in soft cover ready for insertion in a three-ring loose leaf binder. Following initial distribution by the Office of Naval Research, the remaining first run copies will be deposited with the SBA for distribution to requesting members. Upon depletion of that supply, copies may be obtained from the National Technical Information Service.

The value of any publication such as this is proportional to the breadth of its acceptance and use by the community for which it was intended. To this end, the reader is encouraged to make comments and suggestions for corrections and additions to the Executive Secretary of the Scientific Ballooning Association.

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1. INTRODUCTION

Since the end of World War II there has been a steady increase in the use of balloons to gather scientific data for investigations in many disciplines. As scientific sensors have increased in size and complexity, developments in all phases of balloon technology have resulted in giant aerostats capable of lifting scientific payloads weighing several tons to atmospheric levels approximating a space environment. While the operation of such large balloon systems requires special equipment and large, highly trained crews, their relatively low cost, as compared with rocket and satellite platforms, makes them particularly attractive for many applications.

During the same period impressive gains have been made in the miniaturization and integration of electronic circuitry, and in the power density of small electrical power sources. Such gains have kept the so-called "small balloon" very much in the forefront of important scientific activity. Small balloons have been employed for hundreds of flights from sites ranging from pole to pole and in both the Eastern and Western hemispheres. Such balloons can be safely and successfully operated at minimal cost by a few knowledgeable persons, without highly sophisticated or specialized equipment, and thus are especially attractive to the investigator with a limited budget. Small balloons are also ideally suited for use at remote locations where logistics present a problem.

For purposes of this handbook, "small balloons" are arbitrarily defined as balloons with a "gross inflation"¹ of 150 pounds or less. Such balloons would range in size from a few thousand to one million cubic feet in maximum volume.

¹There are many specialized terms used in scientific ballooning. A glossary will be found in Appendix A.

2. SMALL BALLOONS

Small balloons are usually manufactured of either an extensible material, such as natural or synthetic rubber, or a non-extensible material, such as a number of plastic films.

EXTENSIBLE BALLOONS

Examples of the extensible balloon may be seen in the hundreds of flights of meteorological balloons each day, throughout the world, in support of the upper air program of the World Meteorological Organization. These flights are vertical sounding probes, i.e., as the balloon rises, the balloon material extends to accommodate the increase in volume occasioned by the decrease in surrounding atmospheric pressure. Finally the material fails, the balloon bursts, and the flight is terminated. Balloons of this type, capable of carrying payloads of up to 40 pounds are commercially available. However, there are practical limits to their size and capabilities.

ZERO PRESSURE BALLOONS

For larger volumes, heavier payloads, or the capability to remain aloft for extended periods, a balloon made of very thin plastic film is normally employed. It is the plastic "natural shape" or "zero pressure" type of balloon which has been so extensively used for scientific investigation during the last twenty-five years. The term "natural shape" was derived during a study conducted at the University of Minnesota, (1)¹ and describes the theoretical shape assumed by a load-bearing balloon, having zero circumferential or latitudinal stress at all points on the surface of the balloon (2). A real balloon is tailored to approximate this natural shape when at designed ceiling. The actual shape is a function of balloon weight, payload weight, and design altitude. Figure 2-1 shows schematically this variation in shape as a function of "sigma-value", which is

¹(1) Numbers in parenthesis are references at the end of the chapter.

itself a function of balloon material weight, payload weight, and designed maximum altitude. In general, the lighter the payload, the higher the sigma value and the more oblate the shape.

The volume of the lifting gas at maximum altitude is many times its initial volume at the earth's surface. The plastic balloon contains sufficient non-extensible material to accommodate this volumetric change without pressure stress. During inflation and launch, only a small portion of the balloon is involved in containing the lifting gas. A special technique, called the "Huch-Clutch"², enables the launch crew to handle and control the copious additional quantity of plastic material during flight preparation. The Huch-Clutch method is described in detail in section 4 of this manual.

These balloons are designed so that all stress are meridional or longitudinal. In most cases these stresses are shared by the balloon material and either a system of reinforced "load tapes" or a matrix of load-bearing yarns, called "scrim", which are affixed to the balloon material. Either system is designed to reinforce the basic balloon gas-barrier material in critical areas.

During inflation, additional lifting gas over that required for neutral buoyancy is introduced to provide for ascent of the balloon-payload system. When the balloon reaches the intended ceiling, or "float altitude", this excess gas, termed "free lift", is vented to the atmosphere through a "duct" system, such as the one depicted in Figure 2-2. The system cannot ascent higher since the balloon has reached its designed volume and any excess lift will be immediately ducted off. Unlike the extensible balloon the zero pressure balloon does not burst as the duct provides for pressure relief.

RADIATION CONSIDERATIONS

Radiant energy creates a precarious buoyance equilibrium for the

²Named after its developer, William F. Huch, a former engineer at the University of Minnesota.

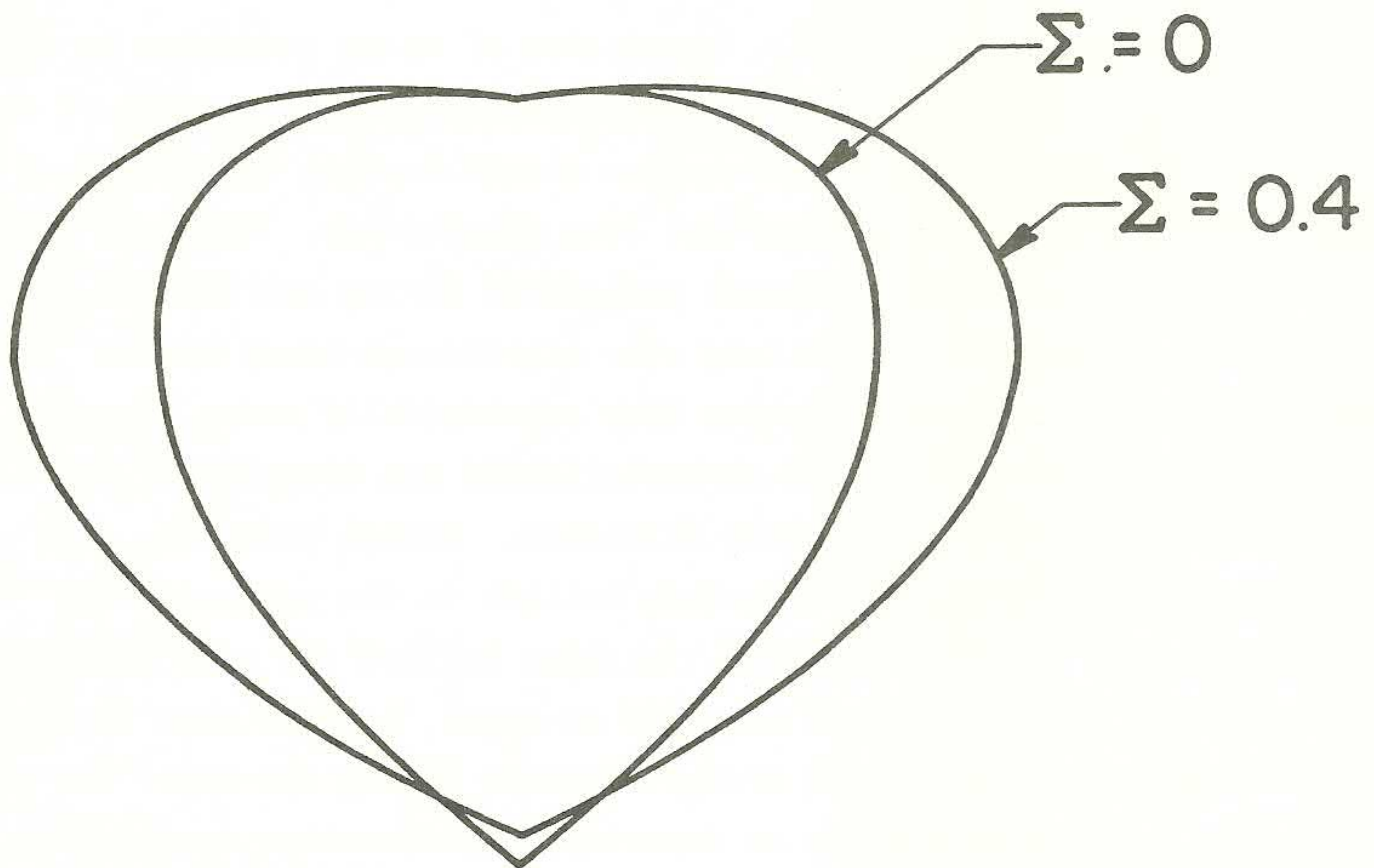


Figure 2.1. Typical Sigma shapes.

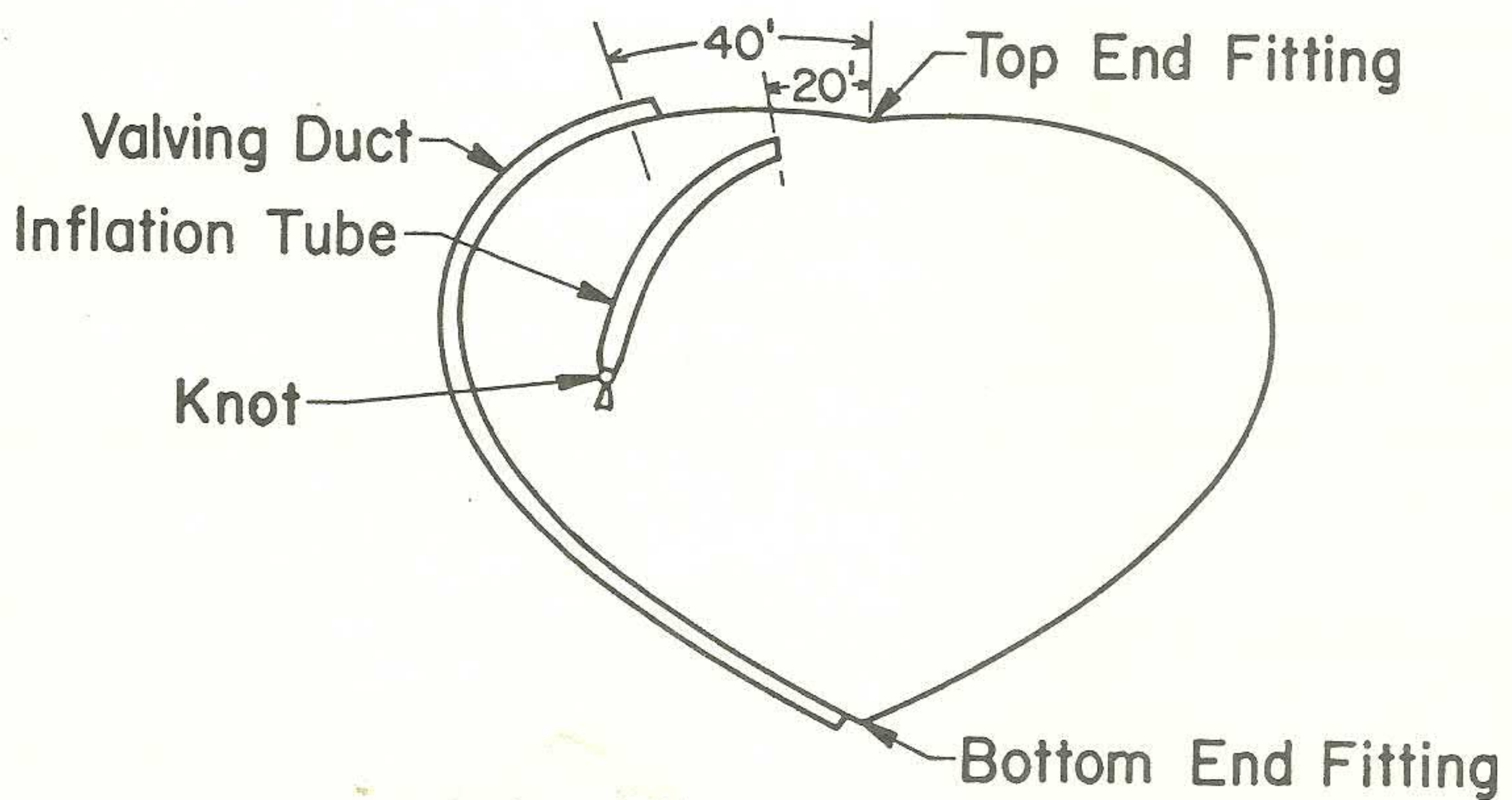


Figure 2.2 Typical balloon appendages.

balloon at float. For example, absorption of solar radiation by the balloon causes heating, expansion and eventual ducting of some of the lifting gas. A decrease in absorption causes cooling of the gas, a decrease in volume, and a resultant loss of altitude. Altitude changes due to radiation changes are most pronounced during sunrise and sunset and during passage of the balloon over significant cloud cover. Although absorptive characteristics vary substantially among commonly used balloon materials, these characteristics are normally of secondary consideration in material selection. Normal procedure with zero pressure balloons is to include ballast in the payload which can be dropped to offset cooling. Without ballast the zero pressure balloon will tend to descend markedly at night, perhaps even to the ground, and to ascend toward design altitude during the day. The amount of ballast carried is an important consideration in planning for flights of zero pressure balloons (3).

SUPERPRESSURE BALLOONS

In recent years considerable use has been made of the "super-pressure" balloon to offset the effects of changes in radiation. The superpressure balloon is sealed and ductless, and is manufactured of a dimensionally stable material which resists expansion of the lifting gas due to heating. Theoretically, if such a balloon were launched and ascended during minimum radiation conditions, it would continue to float at a constant density altitude. At present, economic considerations limit the size of superpressure balloons to relatively small volumes. However, their use with light-weight payloads has been extremely successful, with float times of several months being routine (4).

AIR BREATHERS

One other technique which has been used in minimizing the effect of radiation is worthy of mention. If a zero pressure balloon is fitted with small holes near its base, air will enter the balloon

and mix with the lifting gas. The effect will be to minimize diurnal altitude changes and to extend float duration, but this will be accompanied by an overall reduction in maximum attainable altitude. Experience with this technique is limited.

REFERENCES & NOTES

1. University of Minnesota, 1952, 1953: High Altitude Scientific Balloons, Dept. of Physics Progress Reports on Contract NONR-710(01), Vol. 5 (22 Dec. 1952), 376 pp., and Vol. 9 (3 Dec. 1953), 314 pp.
2. Smalley, J. H., 1965: Determination of the Shape of a Free Balloon, Litton Systems, Inc., Applied Science Div., 40 pp. (Obtainable as AFCRL 65-92 from Air Force Cambridge Research Laboratories, Bedford, Mass. 01730).
3. Braun, R.H., C.S. Tilton, T.W. Kelley, J.F. Dwyer, and J.A. Winker, 1960: Atmospheric Exploratory Devices. In Handbook of Geophysics, The MacMillan Co., New York, N.Y., Chap. 20.
4. Lally, V.E. 1967: Superpressure Balloons for Horizontal Soundings of the Atmosphere. NCAR-TN-28, National Center for Atmospheric Research, Boulder, Colo. 78 pp.

3. PRELIMINARY PLANNING

Paramount among all of the considerations surrounding the operation of scientific balloons must be the safety of personnel and property. Through careful planning and strict adherence to the regulations and safety standards, contained in this manual and its appendices, small ballooning can be successfully accomplished with a minimum of risk. For those investigators new to ballooning, it is strongly recommended that liaison be established with one of the ballooning activities listed in Appendix F. Each of these organizations is dedicated to safe, successful scientific ballooning, and in most cases can make experienced persons available as consultants or field operations supervisors at a nominal charge. Until the investigator and his group gain substantial experience in actual flight operations, it is highly advisable that the services of a professional field operational supervisor be obtained.

HIGH ALTITUDE ENVIRONMENT

Although this handbook is primarily limited in scope to procedures surrounding the actual flight of balloons, it is axiomatic that the equipment flown on the balloon must perform satisfactorily in the high altitude environment. The investigator must ensure that his sensing equipment, recording or telemetry system, power supply, etc. will function properly in the extreme cold and low pressure encountered. Indeed the combination of low temperature and pressure, usually difficult to simulate in the laboratory, may cause a critical malfunction of equipment which has performed well when subjected to either factor alone. Consultation with experienced ballooning organizations will help to circumvent such problems.

REGULATIONS

During preliminary planning, consideration must be given to flight regulations and radio frequency usage restrictions. In the United States and its possessions these are administered by the Federal Avia-

tion Administration (FAA) and the Federal Communications Commission (FCC) respectively. For flights involving foreign airspace, arrangements must be made through the U.S. Department of State.

FEDERAL AVIATION REGULATIONS

Regulations governing the flight of unmanned free-balloon systems are contained in Part 101 of the U.S. Federal Aviation Regulations, pertinent sections of which are contained in Appendix C. These regulations apply to all balloon flights, but are more stringent for balloons larger than 6 feet in diameter, for payloads of more than 6 pounds and/or with a surface density of more than 3 ounces per square inch, or for payload suspension devices or trailing antennas longer than 50 feet which require a breaking force of more than 50 pounds. Most scientific balloon flights fall into one or more of the restricted categories just mentioned. It is important to understand that these flight regulations are in effect to promote safety both in the air and on the ground. They should be followed with meticulous care to avoid any incident arising from a balloon flight. Should the scientific nature of a balloon experiment require deviation from the regulations, a waiver must be obtained from the appropriate FAA office. It should be emphasized that thousands of flights have been successfully accomplished within the limits of these regulations, so it is the unusual experiment which cannot comply. The balloon operator is solely responsible for compliance with the regulations.

a. Operating Limitations

' Location of launch shall not be in a control zone, airway or airport traffic control area. Delineation of these areas will be found in the Enroute and Terminal aviation charts published by the National Oceanographic Survey (1)¹. The location of launch shall also be such that the first 1000 feet of ascent will not be over a congested area or open assembly of persons.

¹Numbers in parenthesis are references at the end of the chapter.

' Weather conditions shall be "visual", i.e., no portion of the flight, below 60,000 feet standard pressure altitude, will be made through or in a cloud ceiling, regardless of the altitude of the clouds; or where the horizontal visibility is less than five miles. Sixty thousand feet is presently designated as the top of the U.S. Airways system. A cloud ceiling is defined as more than 5/10 sky coverage. Authority for determination of cloud cover and visibility is the most current official observation by the U.S. National Weather Service or U.S. military weather observation station nearest the point of the flight in question.

' Ground impact of the balloon, payload, or any part thereof, shall not create a hazard to persons or property not associated with the flight operation. As discussed in following sections, this constraint makes it imperative that the operator exercise the utmost care in selection of components and in construction of the balloon system.

b. Termination Equipment

It is required that the balloon system be equipped with a minimum of two systems or devices, completely independent of one another, for release or cutdown of the payload when the flight is to be terminated by reason of:

- ' Normal completion of the float.
- ' Failure of the flight to ascend above the airways system (60,000 feet) within normal ascent time, or subsequent descent below this altitude. Normal ascent time is not precisely defined, but it should be no more than two to two and one half hours after launch.
- ' Deterioration of the weather conditions of ceiling and visibility cited previously.
- ' Direction by the cognizant FAA control authority.

Likewise the balloon itself must be provided with a minimum of two separate means for termination of its flights. Many schemes have

been employed to terminate the flight of the payload and the balloon. These are discussed in later sections.

c. Marking and Identification

To facilitate visual acquisition of the balloon system by aircraft crews, it must be conspicuously marked. At night, lights are required which are visible for at least five miles. During daylight hours, no special marking requirements exist unless a suspension line or antenna longer than 50 feet is involved, in which case colored bands, pennants or streamers must be used at 50 foot intervals. It is difficult to effectively mark such lines in flight since there is no relative wind to deploy pennants or streamers. It is, therefore, especially important to include information about such lines in flight advisory messages. Parachutes should be constructed of highly conspicuous contrasting colors to enhance recognition of the balloon train during ascent, float and descent. The balloon itself is highly conspicuous during hours of daylight. No attempt should be made to paint or otherwise mark the balloon, since chemical reaction and/or increased absorption of radiation could cause weakening and failure.

Radar reflectors are required on all flights, day and night, to enable air controllers to issue position information to aircraft in the vicinity. Reflectors are strictly required only on the balloon, however, their use on the payload is also encouraged to enhance radar acquisition.

d. Notification and Flight Information

Perhaps no single factor contributes more to the safety of a balloon flight operation than provision of accurate and timely information to the aircraft control network. Careful attention to required flight advisory procedures not only affords the balloon operator the widest possible dissemination of information to alert aircraft in the area, but frequently results in the return of useful information about the balloon flight. FAA personnel and their military counterparts

are normally extremely cooperative as long as the balloon operator is meticulous in complying with the regulations set forth and in providing all information requested. In addition to the initial High Altitude Balloon (HIBAL) advisory notice, or Air Advisory (AIRAD) reports must be made concerning actual launch, termination, and impact. Interim position reports are normally given only upon request by air control personnel. A flight closeout report must be filed upon completion of the flight, or in the event of cancellation or significant postponement. Appendix C contains a check sheet which outlines step by step notification procedures.

e. Derelict Flights

Should a balloon flight fail to terminate or be lost from control for any reason, the operator retains sole responsibility for the flight and he must continue to provide the best available information to the cognizant FAA facility. Appendix C also contains a summary of military regulations concerning derelict balloons. While these are not binding for non-military flights, they provide an informative guide in the event of a derelict flight.

FEDERAL COMMUNICATIONS REGULATIONS

Any radio transmission associated with the balloon flight, for example for telemetry, command/control or radio location, requires prior authorization for use of the desired frequencies. In the United States and its possessions, the FCC exercises overall control of radio frequencies. Local FCC offices are found in most major cities which will assist the balloon operator in obtaining the required frequency usage authorization. In some cases responsibility for coordination of a specific band of radio frequencies has been delegated to another agency, such as the commonly used telemetry band 1435-1535 MHz. Procedures for obtaining authorization within this band are indicated in Appendix D.

It is important to recognize that compliance with communications

regulations serves the operator's own best interests. High power RF energy from other equipment might disrupt data transmissions from the balloon or cause other malfunctions to the flight. When the operator obtains proper authorization, he has in effect received assurance from the coordinating agency that all other known users in the area will remain off the air during the flight.

DIPLOMATIC CLEARANCE

If flights are contemplated which will involve foreign airspace, prior agreement must be obtained from the government(s) involved. Generally, the U.S. Department of State will assist in handling requests for such diplomatic agreements. Requests should include a detailed description of the planned operation, including the scientific objective and the radio frequencies required. Although regulations vary among countries, the International Civil Aviation Organization (ICAO) has provided all member nations with a questionnaire containing guidelines for the evaluation of such requests. A copy of this questionnaire is included in Appendix C. ICAO regulations concerning balloon system markings and flight notification are found in Annexes to the Convention on International Civil Aviation (2). If the operators initial request satisfies the questionnaire, and the operation has been planned to include all precautions set forth in the U.S. regulations, no further information will normally be required.

PROCUREMENT OF BALLOONS

Nominal balloon performance may be estimated using figures 3-1a or b, or by use of the calculator shown in Appendix E2. Many factors must be considered in selecting a balloon for a given mission. The balloon manufacturer will recommend an optimum balloon for the mission, if provided with the following information.

- ' Desired altitude
- ' Total suspended weight
- ' Desired duration, (time at desired altitude)

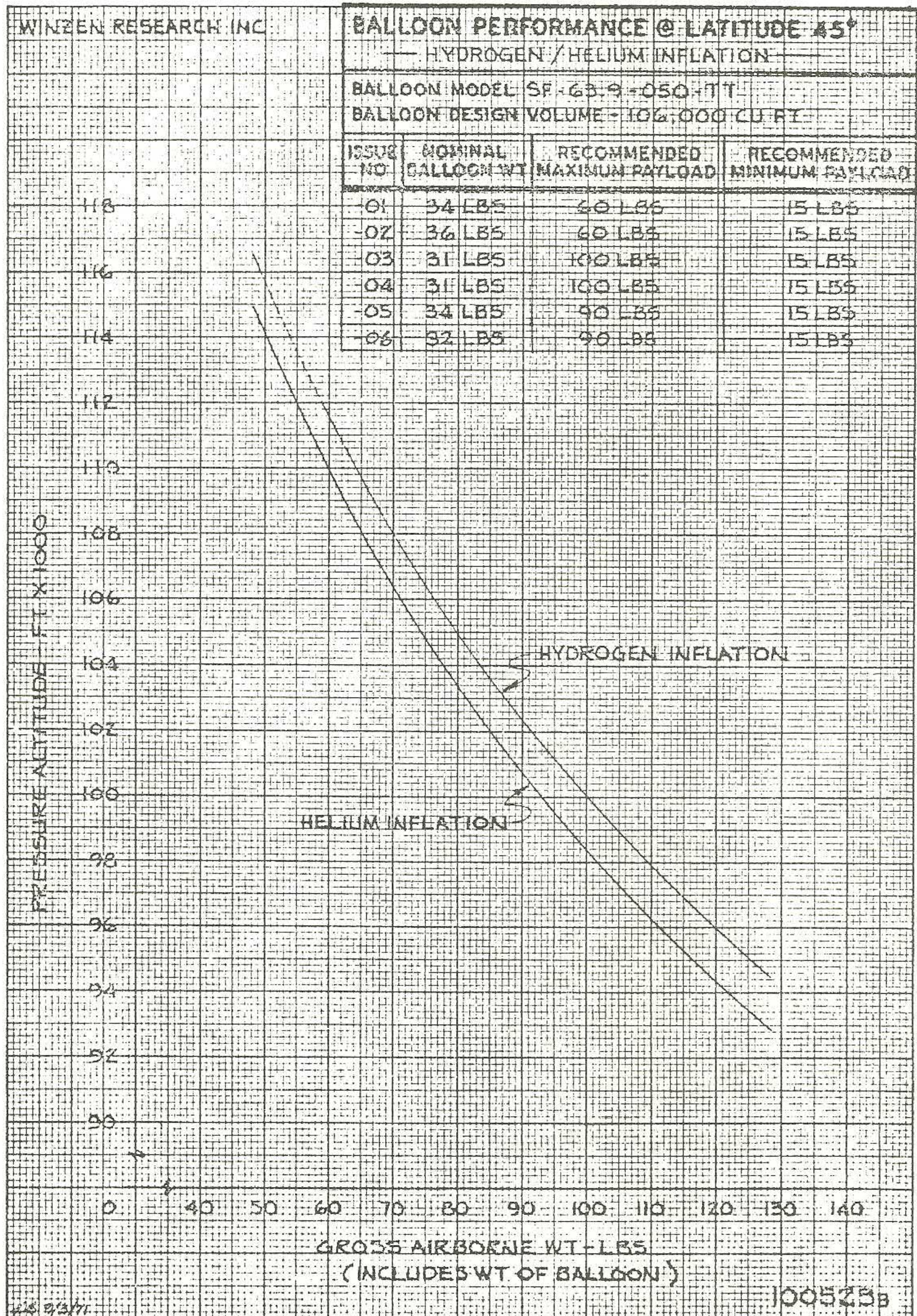


Figure 3-1(a) Nominal balloon performance: for 0.5-mil polyethylene.

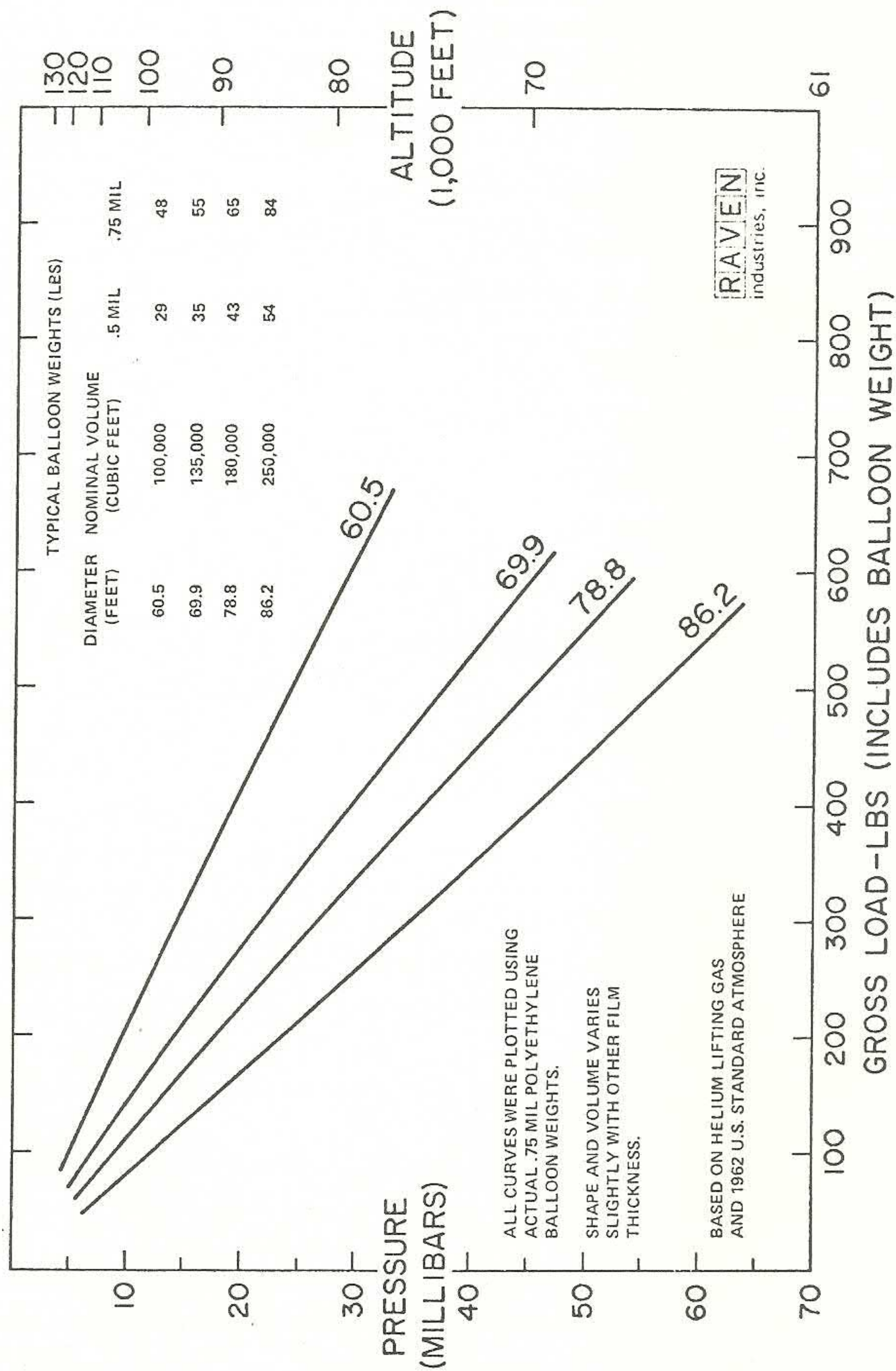


Figure 3-1(b) Typical balloon performance: for 0.75-mil polyethylene.

- Local time and season of launch
- Location of launch
- Special requirements, such as logistics, restricted schedules, etc.

The manufacturer should be requested to provide the following with each balloon delivered:

- Balloon specification sheet (similar to Figure 3-2)
- Balloon performance information (similar to Figure 3-3)
- Bubble length vs. gross inflation (not applicable for rubber balloons)
- Bubble length markings on the balloon
- Print and description of balloon destruct system (similar to Figure 3-4)
- Suitable length of heavy plastic or canvas sheeting for protection of the balloon during layout
- Pressure-sensitive tape for minor balloon repairs
- Unpacking instructions.

A list of balloon manufacturers is contained in Appendix E.

FLIGHT TERMINATION

As previously stated, provisions must be made for reliable, positive termination of the flight of both payload and balloon. Small balloon flights are normally terminated by releasing the suspended payload from the balloon, which in turn initiates balloon destruct and descent.

a. Payload Release

Payload release is normally accomplished by electrical actuation of small explosive devices to sever the main suspension link (3). Actuation has traditionally been by preset timers, of which there are many varieties (4). More recently, lightweight radio command receivers have been used for the primary means of termination with a high degree of success (5), (6). The positive control offered by radio command is preferable to strict preset timer termination. Indeed, radio com-

Project No. 4829

Balloon 3 of 10Serial No. 1185

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
BOULDER, COLORADO

BALLOON SPECIFICATIONS

RFQ NO. 6209-75-C-0698

DATE: 11/8/75

1. MANUFACTURER: Winzen Research		2. PROPOSAL NO: 8729-P		3. PROJECT NAME: Smith	
4. MATERIAL: StratoFilm®		5. FILM GAUGE: 0.5 mil		6. FILM MANUFACTURER: WRI	
7. BALLOON DESIGN		(Attach Load-Altitude Curve)			
7a) Nominal Load: 60 Lbs.		7b) Nominal Altitude: 102,000 Ft. MSL			
7c) Balloon Volume: 106,000 ft. ³		7d) Type (Tailored, Taped, Etc.): Tailored, tapeless			
7e) $\xi = .25$		7f) No. of Gores: 24		7g) Half Gore Width: 7" Top; 6" Bottom	
7h) Max. Gore Width: 100.38 In.		7i) Gore Length: 91.28 Ft.		7j) Surface Area: 11,040 Sq.Ft.	
7k) Inflated Height: 53.6 Ft.		7l) Inflated Diameter: 63.9 Ft.		7m) Mfg. No.: SF 63.9-050-TT-06	
7n) Balloon Wt.: 39 Lbs.		7o) Partial Bubble Weights: NA Lbs. @ Ft.			
lbs. @ Ft.;		lbs. @ Ft.;		lbs. @ Ft.	
8. LOAD TAPES					
8a) Type & Ultimate Tensile Strength: N/A					
9. INFLATION TUBE(S)					
9a) No. of Tubes: 1		9b) Material & Gauge: StratoFilm® 2 mil		9c) Location from Top: 15 Ft.	
9d) Diameter: 6.37" Ea.		9e) Length: 30 Ft.		9f) Horizontal Location: Gore #1	
10. DUCT(S)		0.5 mil			
10a) No. of Ducts: 1		10b) Material & Gauge: StratoFilm®		10c) Area Each Duct: 5.56 Sq.Ft.	
10d) Distance From Bottom End Fitting: 28.17 Ft.		10e) Type of Duct: Horsetail, attached			
11. TOP FITTING					
11a) Type (Attach Dwg. If Non-Std) Fused button		11b) Valve: N/A			
11c) Dimensions:		11d) Weight: Lbs.			
12. BOTTOM FITTING					
12a) Type: Fused button		12b) Dimensions:			
12c) Weight: Lbs.		12d) Load Attachments: 500 lb. test polyester line tied with jar sling knot to form two equal length loops.			

13. OTHER ATTACHMENTS (Cables, Destruct Device, Etc.):

Huch-Clutch 27 feet from apex.
Maximum Recommended Payload 90 lbs.
Minimum Recommended Payload 15 lbs.

APPROVED BY

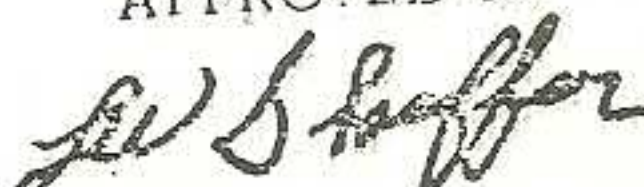


Figure 3-2(a) Example balloon specification:
for a volume of 106,000 cubic feet.

RAVEN INDUSTRIES, INC.

BALLOON SPECIFICATIONS

_____ Copy

Mfg. for: _____ W.O. No. _____
 Contract & Item No. _____
 Balloon Type: 2333-535-386 Ser. No. _____ Prod. Date _____
 Volume: 250,000 cu. ft.
 Theo. Gore Length: 123.0 ft. Cap Length: _____ ft.
 No. of Gores: 32
 Gore Material: POLYETHYLENE Thickness: 0.5 mil.
 Cap Material: --- Thickness: --- mil.
 Load Tapes: TAPELESS lb. test

Number of Inflation Tubes: ONE
 Inflation tube size: 2.5 mil x 15 in. Layflat x 45 ft. long
 Inflation tube location: Station 111, 12 ft. from top

Number of Appendixes: ONE
 Appendix type: HORSETAIL
 Appendix size: 54 in. Layflat x 15 ft. long
 Appendix location: Station 31, 31 ft. from base

End Fittings:

Base: OB1163-2 SPOOL W/3/8" EYEBOLTTop: OB1163-1 SPOOLBalloon is packed: ROLLEDDestruct Device: RIP PANEL, 10 ft. from top end fitting.Reefing Sleeve: N/A, --- mil w/ --- mil tear strip, --- ft. from top end fitting.

Other Specifications: HUCH CLUTCH INSTALLED 31.5 FEET FROM TOP END FITTING. (Y9307 TAPE AND 50 FT OF 4 MIL POLY ENCLOSED.)

Partial Weights:

<u>20</u> ft.	<u>4</u> lbs.	<u>40</u> ft.	<u>14</u> lbs.
<u>25</u> ft.	<u>6</u> lbs.	_____ ft.	_____ lbs.
<u>30</u> ft.	<u>8</u> lbs.	_____ ft.	_____ lbs.
<u>35</u> ft.	<u>11</u> lbs.	_____ ft.	_____ lbs.

Bubble Length: 31.5 ft. for 90 lb. payload with 15 % Free LiftMaximum Recommended Payload 200 lbs.Minimum Recommended Payload 0 lbs.

Weights:

Gross Weight _____ lbs.

Box & Packaging Wt. _____ lbs.

Net Balloon Weight _____ lbs.



Figure 3-2(b) Example balloon specification:
 for a volume of 250,000 cubic feet.

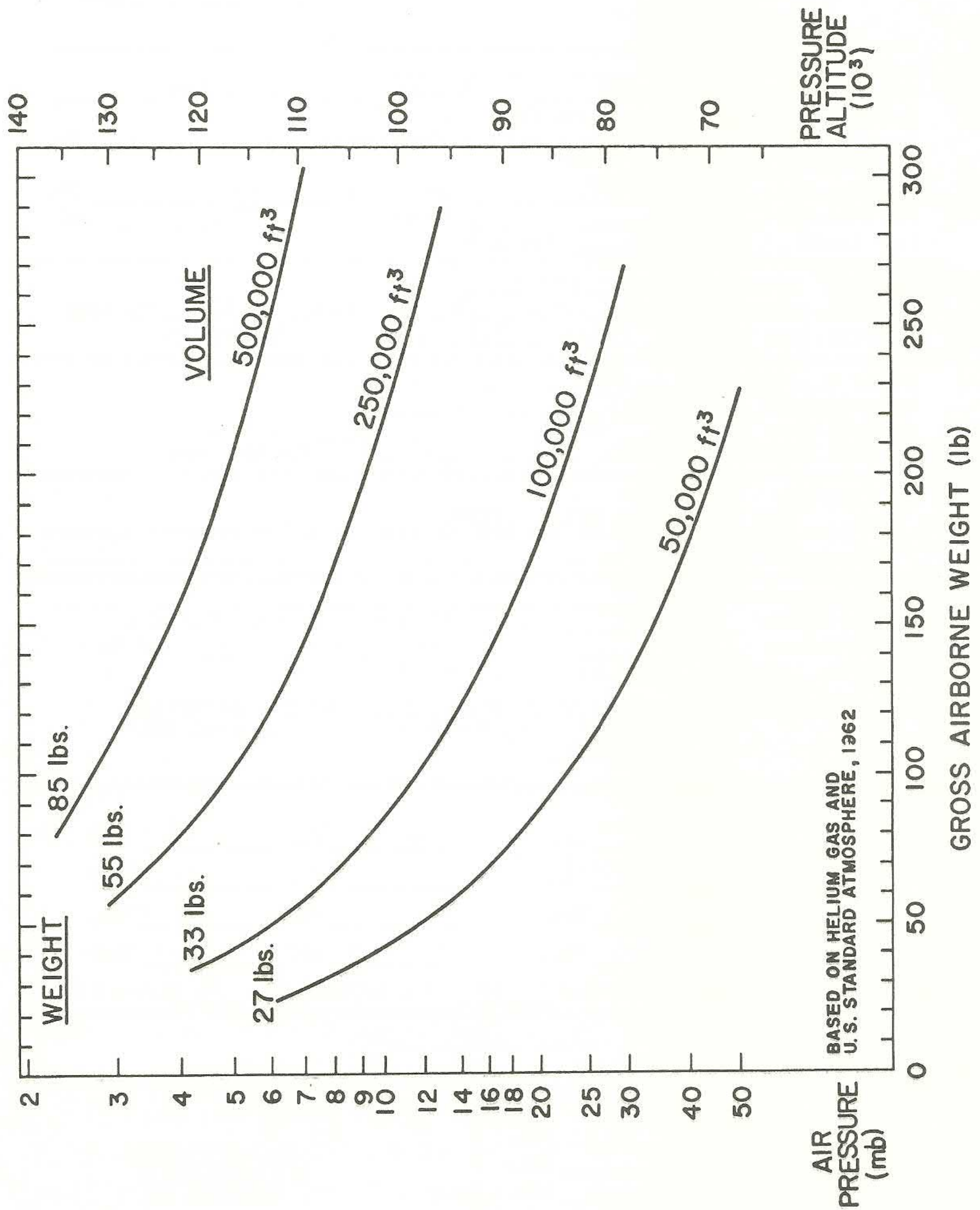


Figure 3.3 Example balloon performance curve.

mand may be required by some FAA regional officials.

b. Balloon Destruction

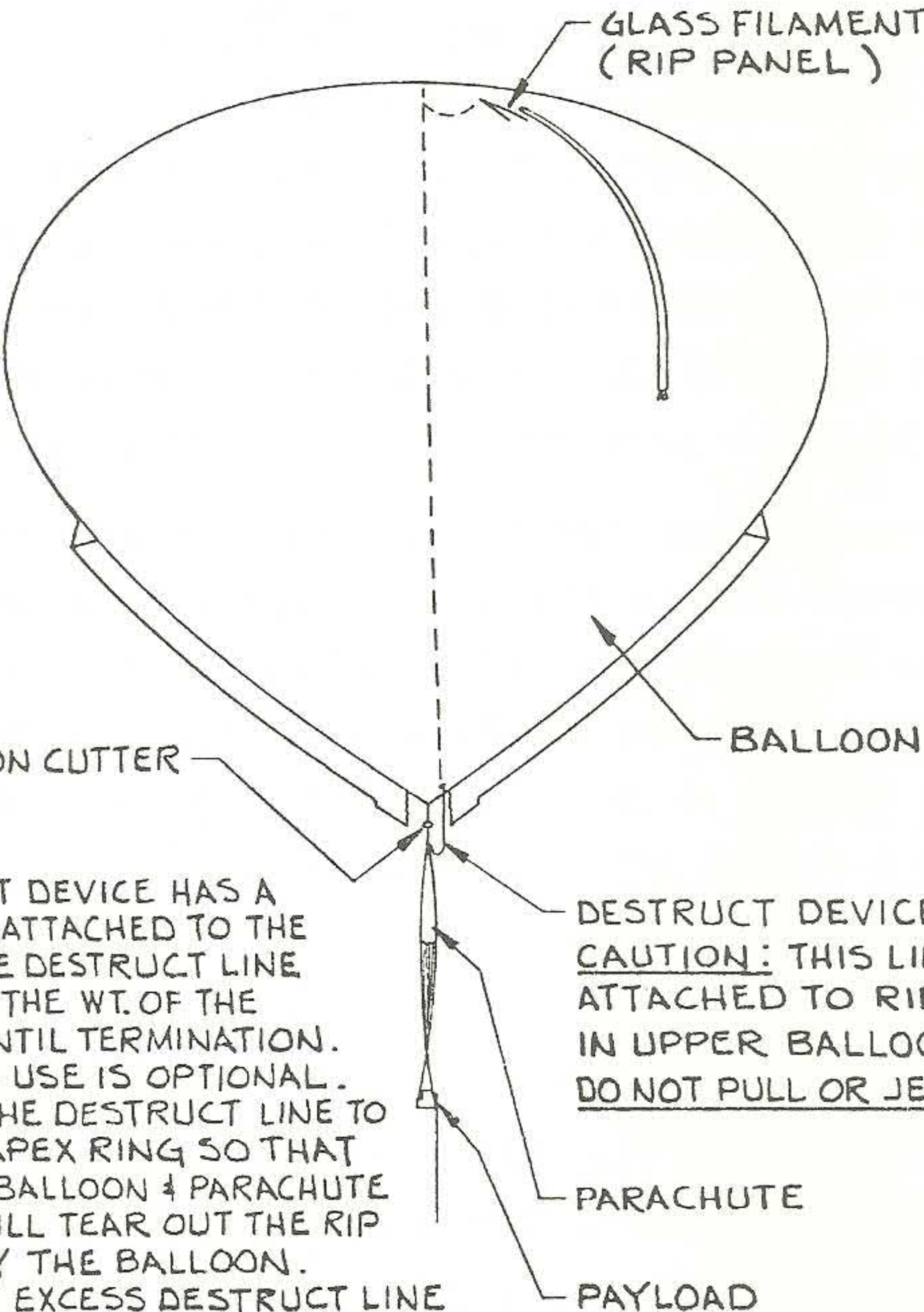
Balloon destruction is commonly effected by a "rip-panel" similar to that shown in Figure 3-4. The rip-panel line is attached to the payload so that as the payload falls away at termination, a large hole is torn in the top of the balloon, releasing the inflation gas, and causing the deflated balloon to descend to the surface. Any other reliable means for releasing the inflation gas is acceptable. A few schemes which have been used successfully in the past are:

- ' Top-mounted valve, actuated by timer or radio command
- ' Pyrotechnic destruction of a section of balloon material
- ' Balloon inversion. A small weight, suspended off-center from the balloon apex, will cause the balloon to invert at payload separation, allowing the gas to escape through the ducts. (This scheme should only be used with low mounted ducts.)

c. Termination

Termination must be reliable, whatever method is chosen. Reliability is increased by the use of redundant systems, as required by FAR Part 101. As schematically shown in Figure 3-5, each primary device is backed up by a completely separate device capable of terminating the flight. Systems similar to this one have been successful for numerous flights in the past. In Figure 3-5, the primary termination is by radio command actuation of two, separately powered squibs. In the event this fails, the main or backup termination timers actuate their respective squibs at the end of preset periods. As the package and parachute drop away, the rip-panel lines are pulled taut, mechanically arming the delay squibs, and initiating large tears in the top of the balloon. After the designed delay, the rip-panel lines are severed by the delay squibs. It has been found advantageous to sever the rip-panel lines to prevent any possibility of fouling the parachute.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



NOTES:
 302496 DESTRUCT DEVICE HAS A BREAKAWAY LINE ATTACHED TO THE APEX FITTING & THE DESTRUCT LINE FOR SUPPORTING THE WT. OF THE DESTRUCT LINE UNTIL TERMINATION. DESTRUCT DEVICE USE IS OPTIONAL. IF USED, ATTACH THE DESTRUCT LINE TO THE PARACHUTE APEX RING SO THAT SEPARATION OF BALLOON & PARACHUTE AT TERMINATION WILL TEAR OUT THE RIP PANEL & DESTROY THE BALLOON. IF NOT USED, CUT EXCESS DESTRUCT LINE AT EXIT POINT THRU BALLOON WALL & PUSH BALANCE OF ATTACHED LINE INTO BALLOON. COVER EXIT HOLE WITH A 2" X 2" PC. OF WRI SSA-10 TAPE OR EQUAL.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON			DR <i>APB</i>	DATE <i>8 MAY 70</i>	TITLE TYPICAL BALLOON & FLIGHT TRAIN SHOWING 302496 DESTRUCT DEVICE SYSTEM	WINZEN RESEARCH INC.
FRACTIONS +	DECIMALS +	ANGLES +	CH <i>RWM</i>	5-8-70		
-	-	-	APP <i>[Signature]</i>	5-8-70		
MACH. FINISH						
MATERIAL					DRG. NO. 100770	
MAT. SPECS.						
NO. REQUIRED						
SCALE NONE					WT.	

Figure 3-4 Example of destruct device information.

CAUTION

For very light payloads a short free-fall may be required to generate sufficient force for actuation of the delay squib and/or rip-panel.

Explosive devices such as squibs must be specially constructed to fire properly in the low density air encountered at high altitudes (3).

Nominal parachute performance may be estimated Figure 3-6 or the calculator shown in Appendix E-5. Parachute size should be selected to give the payload a sea-level descent rate of 25 feet per second or less, to minimize damage to the equipment and hazard to persons or property. As in the case of other procurement, the parachute supplier should be provided with all details of the operation so that he can recommend a chute of proper size, type, material and construction. In particular the supplier must be informed of the planned deployment altitude, whether the extended parachute will have top-mounted equipment and that the parachute will be bearing the weight of the payload at the time of termination. Parachutes are normally flown extended for reasons of simplicity and reliability. No separate remote opening operation need be provided for.

WARNING

The high elasticity of some parachute materials can drive the canopy into the payload, causing fouling and subsequent free-fall of the payload.

The extended parachute, which should always be constructed of highly conspicuous colors, enhances visibility of the system during daylight hours.

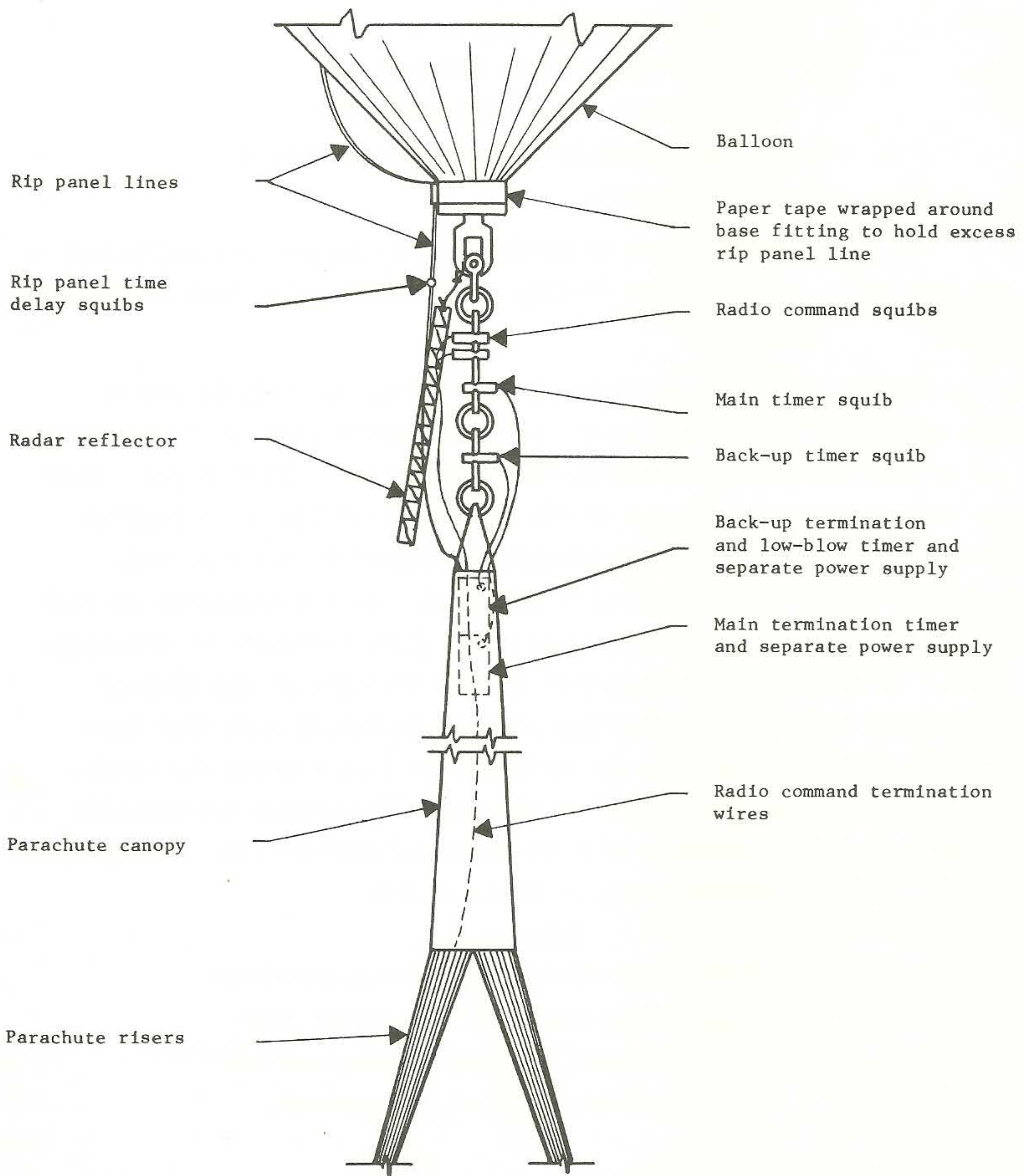


Figure 3-5 Flight train configuration showing termination devices, parachute and radar reflector.

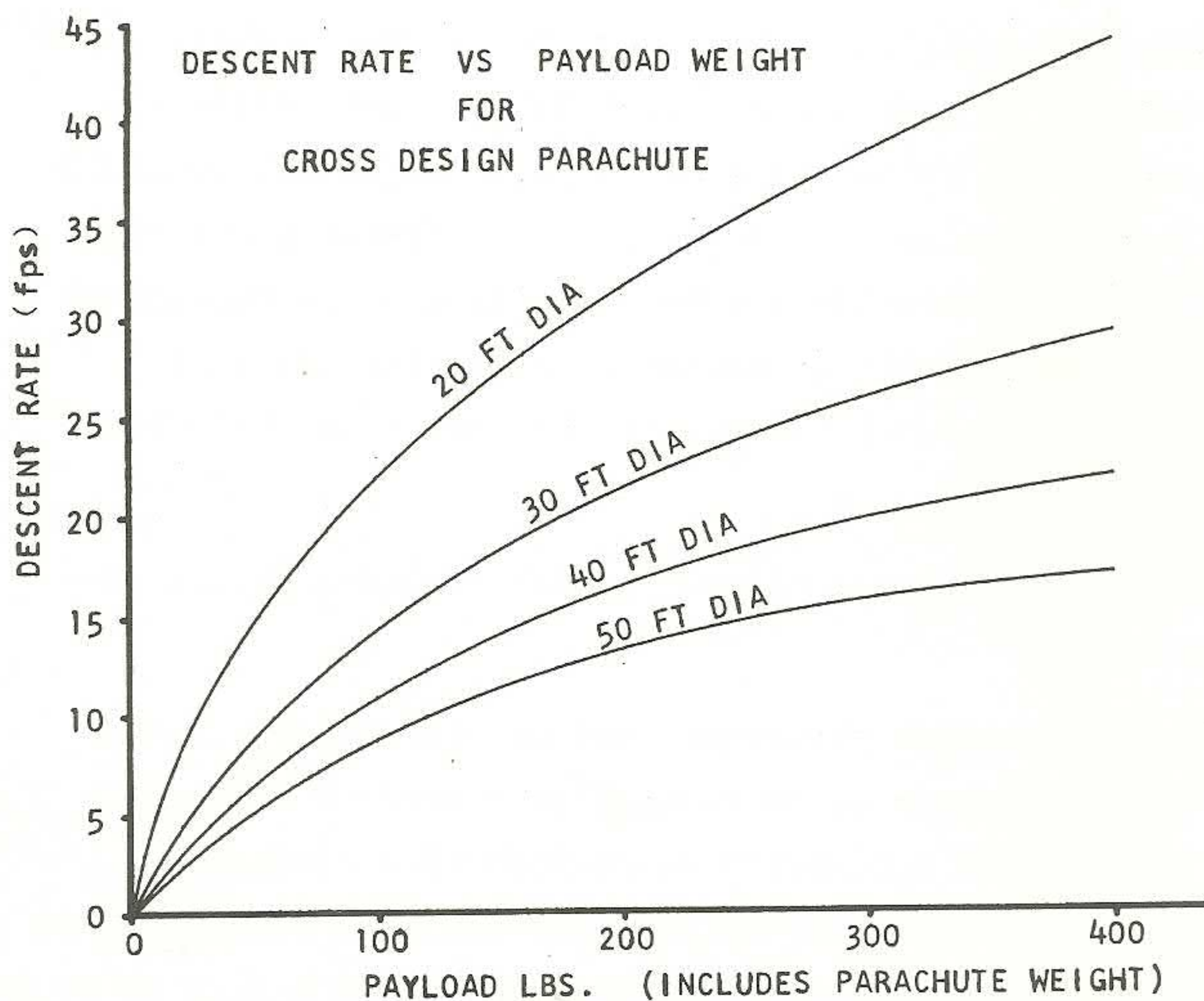
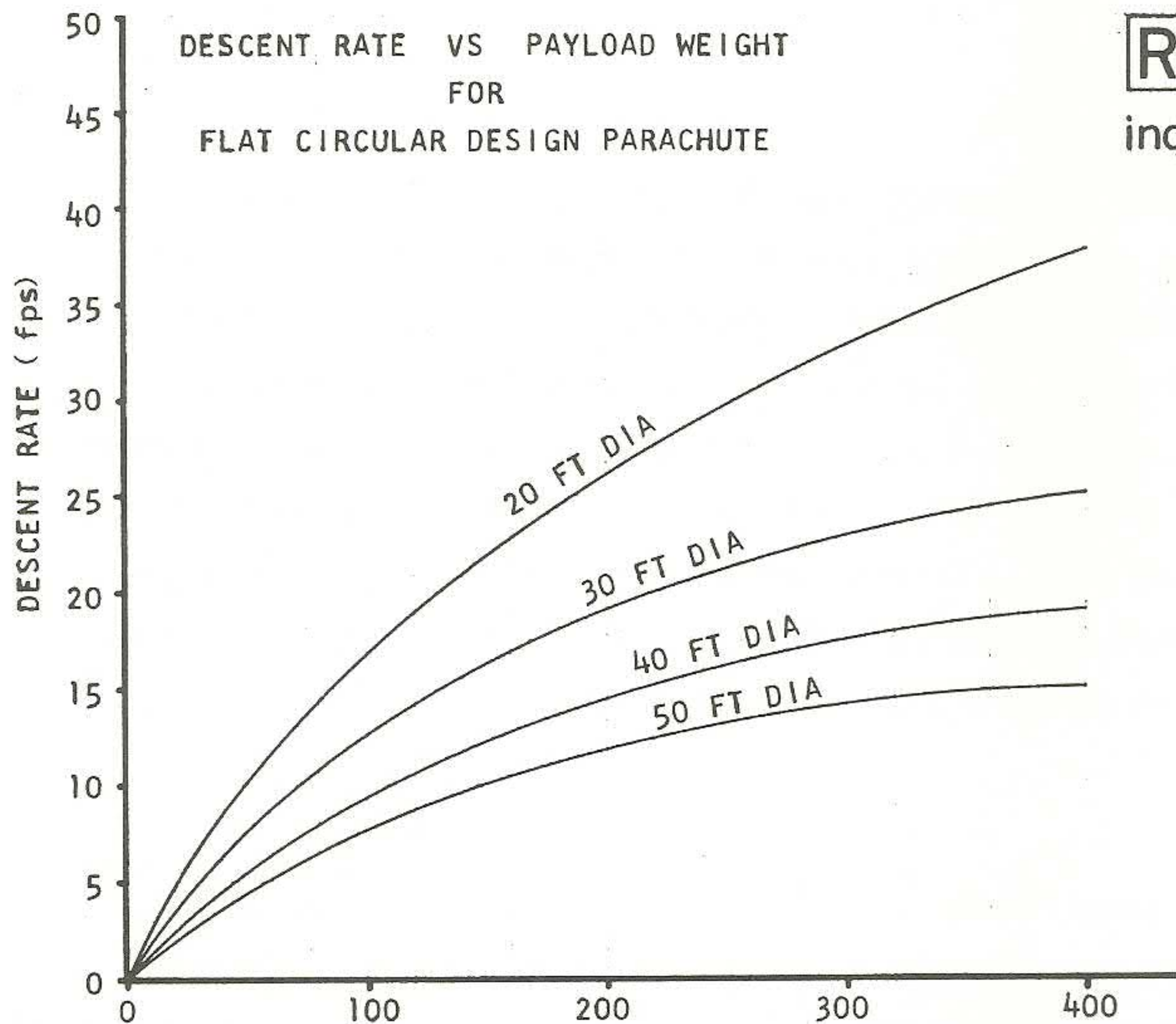


Figure 3.6 Descent rate of two parachute designs at sea level.

RADAR REFLECTORS

Suitable radar reflectors must be attached to the balloon. In addition, it is a good safety practice to affix a reflector to the payload, since after termination it may follow a trajectory quite different from that of the balloon. "Home-made" reflectors, such as the one shown in Figure 3-7 have produced good radar returns at distances up to 100 miles. They can be easily fabricated from aluminum foil at the launch site. Commercial corner reflectors can be procured which, though heavier, provide a better radar target. Figure 3-8 shows examples of this type of reflector.

SITE SELECTION

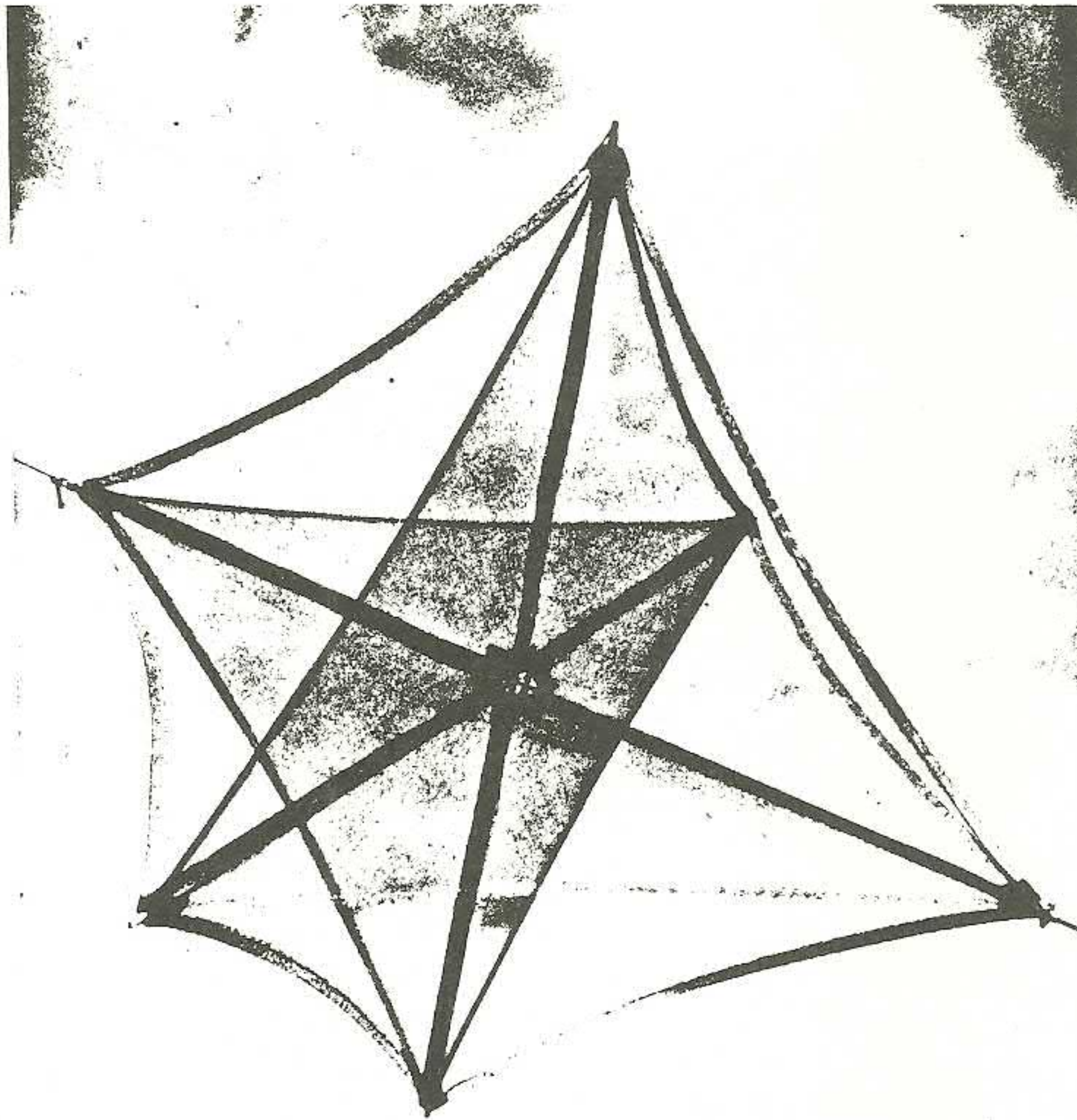
The general geographic location of the launch site is usually dictated by the scientific phenomena under investigation. However, if the experiment is not critically dependent on location, the scientist may wish to consider an established base for his flight program. Comprehensive descriptions of a number of established launch sites are contained in Reference 7. While these sites were considered primarily for tethered balloon operations, many are suitable for free balloon flights, and the support available may be of assistance to the investigator. Similarly, most of the operational activities listed in Appendix F have launch sites and can provide support near their home location.

The investigator who selects his own launch location should consider several criteria:

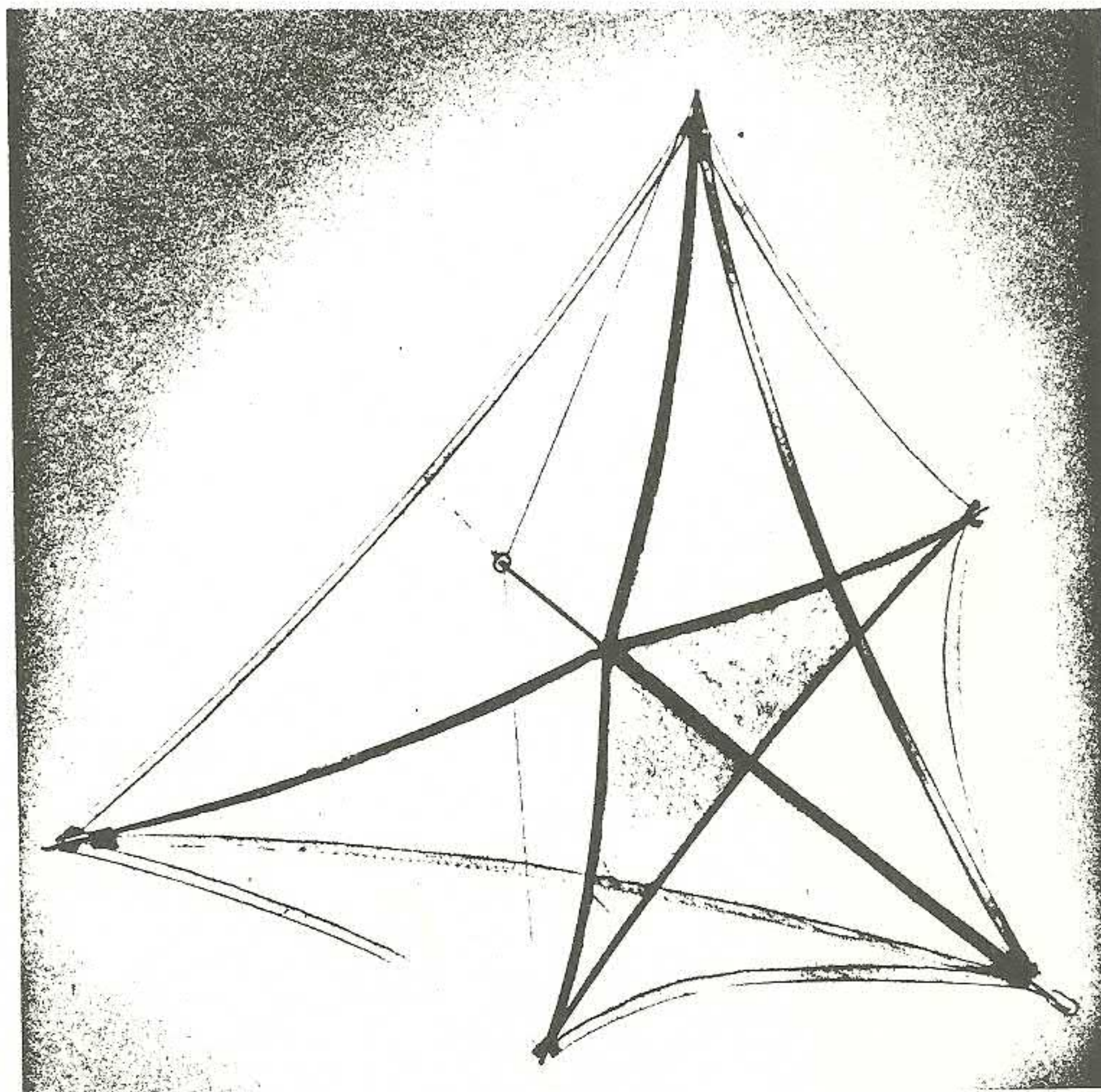
- ' Climatology of surface phenomena, and of winds aloft characteristic of the area. A study of local weather records will usually reveal seasonal and diurnal tendencies of surface wind conditions, clouds, and precipitation which are helpful for planning purposes. On the other hand, a review of weather conditions may cause a site to be rejected entirely. Climatological data can be obtained from the National Weather Records Center, and from local public libraries, weather offices, or Chambers of Commerce.



Figure 3-7 Accordion-Folded Aluminum Foil Radar Reflector.



Sucal Radar Reflector, Octahedral MK-016
Hypotenuse 3 feet, Weight 15 ounces



Sucal Radar Reflector, Tetrahedral RR-32/AM
Hypotenuse 4.5 feet, Weight 17 ounces

' The site should be safely clear of electrical power lines, fences, and buildings. Its surface should be free of ditches, rocks, and other hazardous obstacles.

' The site should provide an initial ascent trajectory away from populated areas or high-density aircraft lanes, such as airways or approach and departure corridors.

' Availability of a shelter from winds, such as a remote building, line of trees, or a large natural depression, is advantageous.

' A telephone or other means of communication to facilitate contact with the nearest FAA facility and weather office should be available.

Although the operator must pay close attention to avoiding areas of high aircraft density, a small civil airport may provide the best and safest launch site in a given area. Special permission must be obtained from the local FAA facility for operating from such a site. These sites are usually well prepared and free of obstructions. Also, airport personnel are cognizant of local air traffic and can usually provide communications with FAA control centers for flight notification purposes.

REFERENCES AND NOTES

1. Department of Defense: En Route Charts, High and Low Altitude, Revised Monthly. (Flight information publication available from Director DMAAC, Attn: PDR, South Annex, St. Louis AFS, MO 63125).
2. International Civil Aviation Organization: Annexes 7 and 15 to the Convention of International Civil Aviation. (Available from the ICAO, International Aviation Building, 1008 University Street, Montreal, Quebec, Canada.)
3. Technical information on squibs and explosives may be obtained from E.I. du Pont de Nemours & Co., Inc., Wilmington, Delaware 19898, Attn: Explosives Department, Chemical Products Sales Division.
4. Cooper, O.L., 1971: Timers for Balloons, Facilities for Atmospheric Research 16, National Center for Atmospheric Research, Boulder, Colorado, pp 10-12.
5. Department of the Navy, 1971: Skyhook BUCKSHOT II, unpublished Office of Naval Research Operations Report, September, 11 pp.
6. Williamson, P. Roger, 1975: An Expendable Command Termination System for Scientific Balloon Flights, Dept. of Applied Physics and Information Science, University of California San Diego, Annual Report ONR Contract N00014-69-A-0200-6053, 30 July 1975, 30 pp and Appendices.
7. Meyers, Philip F., 1968: Tethered Balloon Handbook, AFCRL-69-0017. Goodyear Aerospace Corp. Report, 233 pp.

4. LAUNCH PROCEDURES

This section is concerned with the responsibilities of the launch director, pre-launch preparations, inflation, launch and flight of the balloon system.

DESIGNATED LAUNCH DIRECTOR

It is important that one individual be specifically designated to be in charge of the operation. This person should be experienced in balloon operations, and all personnel involved should be in mutual agreement to abide by his decisions concerning the operation. The designated launch director is responsible for the safety of personnel and property involved, for the selection of the launch site, and for pre-launch preparations, inflation, tracking, and when required, recovery of the balloon system.

SITE PREPARATION

The launch director should become familiar with the general surface weather conditions at the launch site, and the characteristics of upper level winds for the season and geographical area of interest. This information is useful in planning optimum time for launch and probable flight track and flight duration. He must also familiarize himself with the terrain surrounding the launch site, bearing in mind the safety of personnel and equipment. Arrangements for workspace, power, weather information, and communications at the launch site must also be made by the launch director. During these preliminary contacts, the launch director should clearly identify himself as the single official spokesman for the ballooning group.

LAUNCH PREPARATION

The period of time between unpacking of the balloon and the actual lofting of the payload on launch, is the most critical to the success of a well planned balloon flight. A number of factors, such as balloon damage during handling, sudden changes in wind or weather, improper

rigging and test procedures or improper inflation can doom the effort, literally before it gets off the ground. The launch director will make the decision to start inflating the balloon only when all other preparations are complete, when all members of the crew are thoroughly briefed as to their duties, and when he has a high degree of confidence in continuing satisfactory weather conditions.

LIFTING GAS SUPPLY

A sufficient quantity of lifting gas to quickly inflate the balloon must be available at the inflation site. The required amount of gas is calculated by obtaining an accurate balloon weight and suspended equipment weight, which together constitute the gross weight. Free lift, 10% to 25% of the gross weight, is then added to the gross weight to yield the "gross inflation", or total lift required to cause the system to rise to the balloon's designed altitude. This information is used to determine the capacity of the gas supply system to be prepared. (Figure 4-3.) In general the more gas cylinders used, over and above the minimum required, the less will be the inflation time. Where logistics present no problem the launch director may consider expediting the inflation by manifolding additional cylinders.

WARNING

Pay Special Attention to the High Pressure Gas
Safety precautions contained in Appendix E-9.

WIND

In general, the launch operation is enhanced by a light, steady wind of not more than ten knots in the first few hundred feet of the atmosphere. Surface wind indications may be misleading, since in the presence of a strong temperature inversion, wind speed and direction may vary markedly quite close to the ground. Winds in this "launch layer" should be estimated using one or more small weather balloons

tethered at the higher levels.

GROUND HANDLING

When unpacking the balloon the manufacturers instructions should be observed to ensure correct orientation and to avoid twists and folds. Extreme care must be exercised during actual manipulation of the material to avoid damage. Material should be lifted into place, never grasped and pulled into place. Personal jewelry, watches, buckles, or other clothing protruberances should be removed. Many balloon operators advocate the use of light cotton gloves when handling balloon material.

CAUTION

Jewelry or other protruberances should be removed prior to handling balloon material.

The balloon is laid on the protective ground cloth provided by the manufacturer in preparation for inflation and weigh off. (Figure 4-4.)

EQUIPMENT CHECKS

Before beginning inflation, all balloon control instrumentation and scientific equipment should be checked for proper performance in accordance with carefully prearranged check lists. Only after the launch director has received a "go" from the scientist and the technician responsible for the balloon control equipment, should he proceed with the inflation.

CONSTRUCTION OF THE BALLOON "TRAIN"

In addition to the scientific payload, the following equipment

must be included in the suspended system, or "train", as minimum safety equipment:

- Radar reflector
- Primary termination device
- Independent backup termination device
- Parachute for payload descent
- Flashing lights and/or colored pennants where applicable
- "Reward" tags identifying the operator
- Warning tags when hazardous equipment or substance is involved

A typical flight train is shown in Figure 3-5.

INFLATION

Proper inflation of the balloon is critical. If too little lift is provided the system may be damaged by ground obstacles at launch, or it may fail to rise to the designed float altitude. If too much lift is provided, an excessive rate of rise may destroy the balloon during ascent. The inflation problem is basically three-fold: Determination of required free lift; Expeditious transfer of the lifting gas; and accurate measurement of the true lift in the balloon.

FREE LIFT

Factors which affect rate of rise are time of day, season, geographical location, and the lapse rate of the atmosphere and of the lifting gas. Experience has shown that for small balloons, free lifts of from 10% to 25% have resulted in satisfactory ascent rates, with the higher percentage being used most frequently. Generally, a day time ascent requires less free lift because of the heating effect of solar radiation.

GAS TRANSFER

The actual inflation of the balloon should begin only after all other preparations have been made and all personnel can direct their attention toward launching the flight as soon as possible. The

balloon "bubble" is most vulnerable to damage from ground winds during the initial stages and it should be held by the apex until it contains enough lift to support its own weight. (Figure 4-9.) The inflation tube should be kept free of slack and twists. It is frequently necessary to follow movements of the balloon to prevent buckling of the tube where it enters the balloon. The balloon is watched closely for signs of damage or gas leakage.

CAUTION

Never launch a balloon with known damage.

The launch director will stop the operation and ascertain whether repair is feasible or the launch should be cancelled.

TRUE INFLATION

Determination of the true lift contained in the balloon may be accomplished using the abbreviated inflation tables, for helium or hydrogen, contained in Appendix E. The method described involves computation of lift using temperature of the gas and initial and final pressures of gas cylinders of known volume. The Huch-Clutch method, described in the following section, involves an actual "weigh-off" (Figure 4-12) and is simpler and perhaps more accurate. However, when using it many operators also follow the metering computations as a check.

HUCH CLUTCH LAUNCH PROCEDURE

This section contains a description of a hand-launched balloon system employing the Huch Clutch technique. In addition to the narrative, an artists concept (Figure 4-2) and sequential photographs of an actual balloon launch (Figures 4-3 through 4-16) are presented.

The balloon will be packaged in the shipping container in a configuration similar to that shown in Figure 4-1. The base of the

balloon is contained in a polyethylene wrapper which in turn is attached with a nylon line to a loop formed in the balloon. This loop has been previously wrapped with a protective covering. The top of the balloon, or bubble, with its inflation tube is then packed in the top of the box. The Huch Clutch launch procedure is described below.

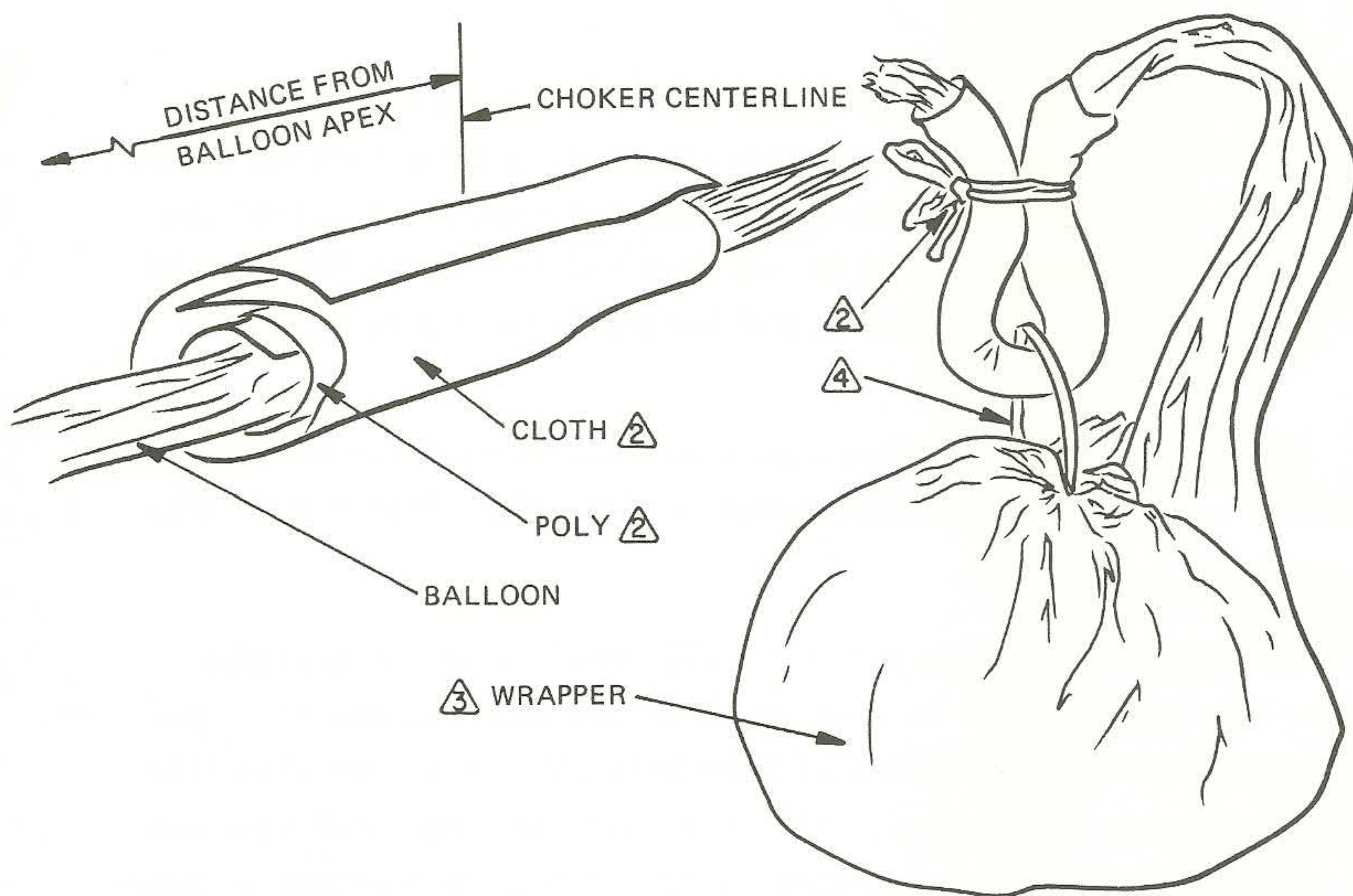
- a. If possible a wind screen or the lee side of a building should be used for shelter to minimize the wind effect on the balloon bubble during inflation.
- b. A tare weight is attached to the wrapped loop. This weight is equivalent to the weight of the equipment to be suspended below the base of the balloon plus a weight representing the desired free lift.
- c. A safety line attached to the sling is secured to a truck bumper or other anchor point. This line should be long enough to allow the bubble to lift the encased balloon and tare weight clear off the ground when sufficient lifting gas has been introduced.
- d. Inflation gas is introduced through the inflation tube of the balloon bubble and inflation started in the shelter of the wind screen. Inflation is continued until the inflation gas in the bubble lifts the entire balloon and tare weight off the ground. The inflation tube is then knotted with a tight, single overhand knot to prevent gas escape.
- e. The entire balloon and tare weight are then moved just outside the wind screen on the downwind side. The wrapper is removed from the bottom of the balloon and the balloon rolled out in a downward direction on the ground cloth provided. The parachute and payload are tied to the base of the balloon. When ready for launch, two men remove the safety line and hold the balloon by the wrapped loop. The tare weight is carefully removed from the loop. The tie and the wrap are removed and the bubble is held by hand. The payload is held by one or two persons. An additional person, stationed at the parachute,

applies tension to the system by pulling on the parachute risers. The bubble is then released, and the balloon rises, picking up the payload. If the wind velocity is high, the payload men may have to run downwind to prevent the payload from dragging on the ground before it is picked up by the balloon.

This launch technique has been successfully used for hundreds of small balloon flights and can be accomplished with minimum training.

TRACKING THE BALLOON

The balloon system is usually highly visible during daylight hours. Its position may be closely estimated with the aid of simple equipment. Using a theodolite or hand-held clinometer for elevation angle, a compass for bearing, telemetered or estimated altitude, and the horizontal distance calculator, Appendix E4, the position in bearing and distance may be recorded. The telemetry antenna, if highly directional, may also be used for azimuth and elevation determination. If radar facilities are nearby, the controlling agency will frequently assist the balloon operator to track the flight, particularly during ascent and descent. Principles of aircraft tracking are outlined in Appendix E7.



NOTE 1) With balloon evenly stacked, accordin pleat across gore half width.

- 2) At a specified distance from the apex (ref.—customers specifications) a narrow 2 mil red poly wrapper and a 3 foot long cloth (example: roll toweling) wrapper shall be wrapped with small overlap tightly around balloon, then folded and tied with 3000 lb. test hard brand nylon line. (Wrap line around 2 times and tie in a shoelace bow and safety with a double bow.)
- 3) The lower part of the balloon is to be accordin folded to within 5 feet of choker and wrapped in a colored *STRATOFILM* wrapper by tying opposite corners of the wrapper together.
- 4) The choker loop is tied thru and close to the crossed poly ties to support lower portion of balloon.
- 5) Weight information required:
 - a) Gross weight includes balloon, shipping container, vapor barrier and launch packaging.
 - b) Launch packaging (huch-clutch) includes nylon tie lines, cloth, poly wrap and balloon.
 - c) Launch tare includes cloth, poly wrap and nylon tie lines.
 - d) Balloon net weight (subtract launch tare from launch packaging wt.).
- 6) Leave 18 inches of balloon bottom end and base fitting out of package.
- 7) Bubble length set for next highest load above customer specification.
- 8) Pack in fiber box per mil-PPP-B-636, Type I, Class I, Style SFF. Line box with *STRATOFILM* or poly.
- 9) Heat seal completed huch-clutch assembly in a red *STRATOFILM* or poly bag.

Figure 4-1. Balloon packaging for Huch Clutch launch.

(Reproduced permission of Winzen Research Inc.)

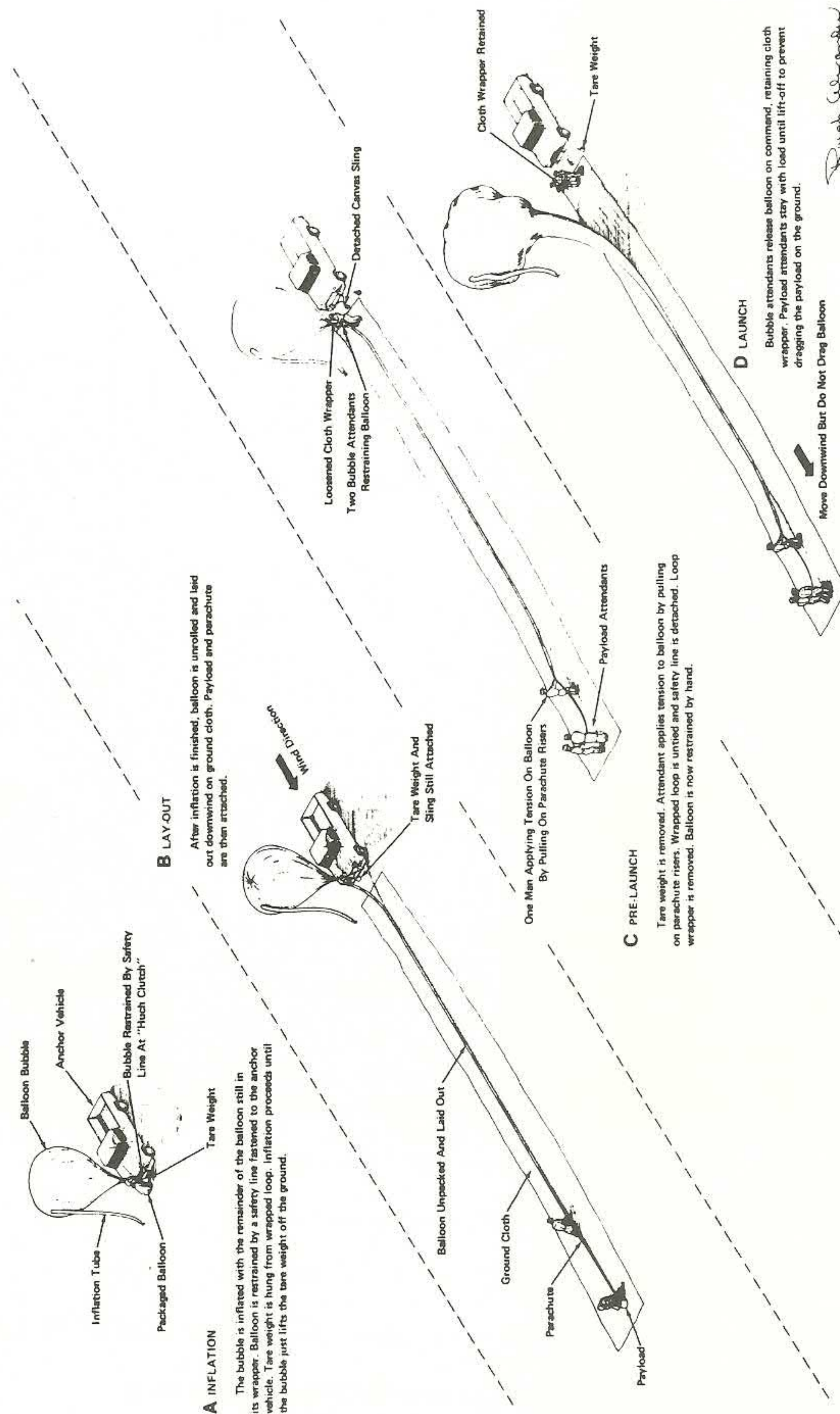


Figure 4-2 Sketch of the Huch Clutch launch technique.

Reproduced courtesy of Winzen Research, Inc.
Illustrations by Sheldahl



Figure 4-3. A typical balloon inflation system assembled and ready to use. It consists of a block manifold with 12 high pressure hoses connected to the gas cylinders, a gas pressure gage, a control valve, a length of good quality garden hose and a gas diffuser. The diffuser is secured to the open end of the garden hose.

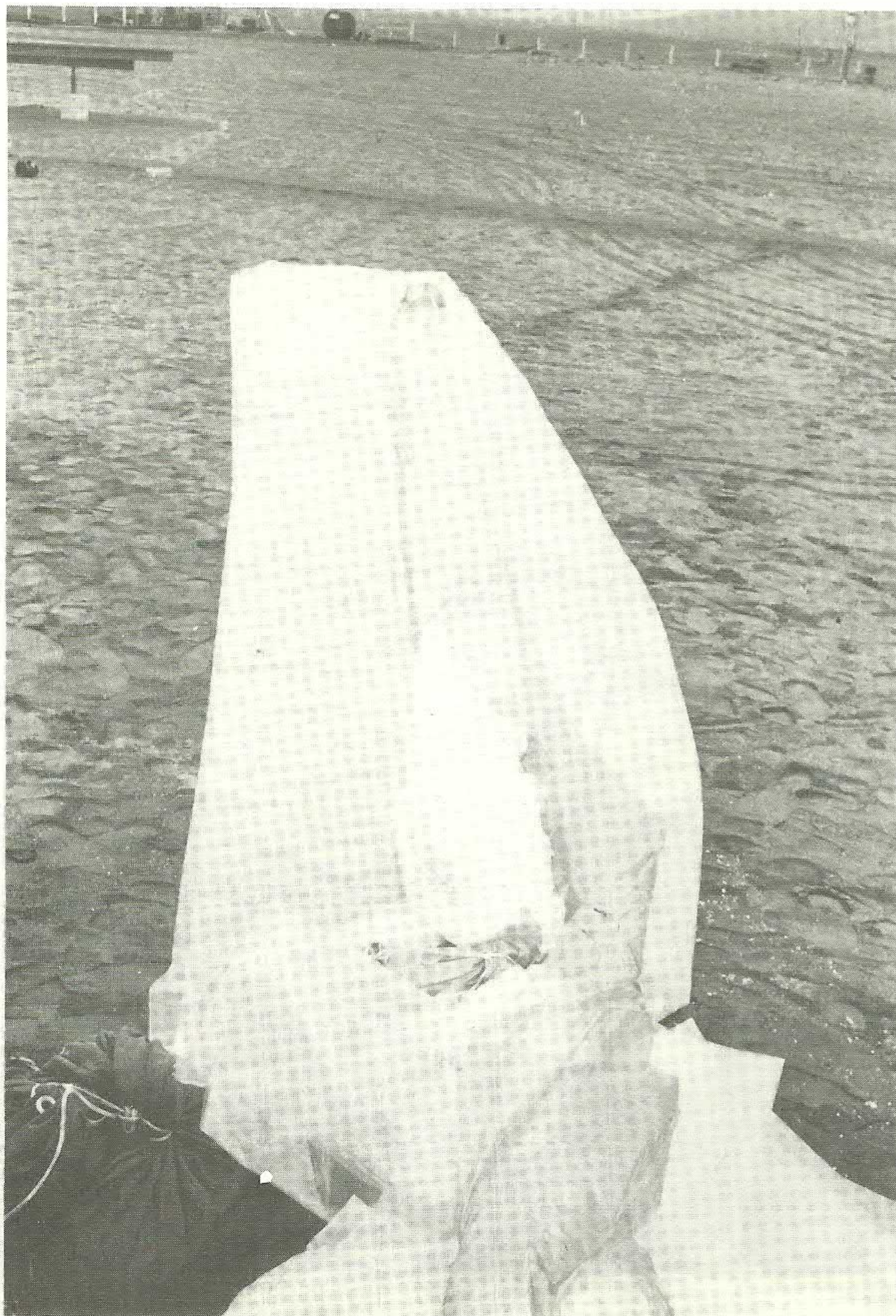


Figure 4-4. Balloon bubble, still encased in protective wrap, is laid out on a heavy sheet of plastic for protection from abrasive surface. In this position the bubble is measured for proper length and proper installation of the Huch Clutch. After wrap is removed, the installation of inflation tube and apex fitting should be inspected for possible damage.

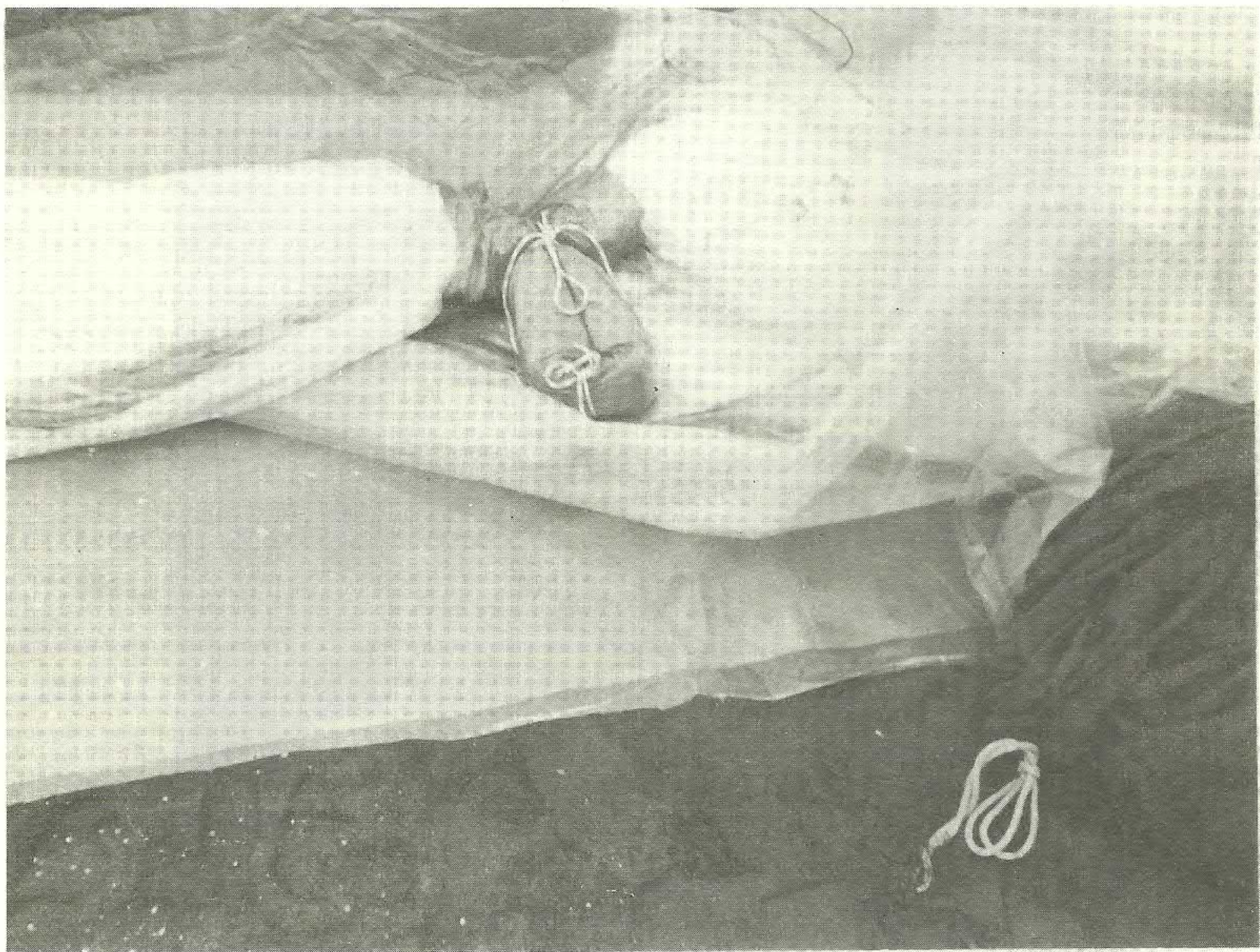


Figure 4-5. Detailed view of the Huch Clutch



Figure 4-6. Pressure sensitive filament tape across the opening of the gas diffuser may be used to further diffuse gas flow.

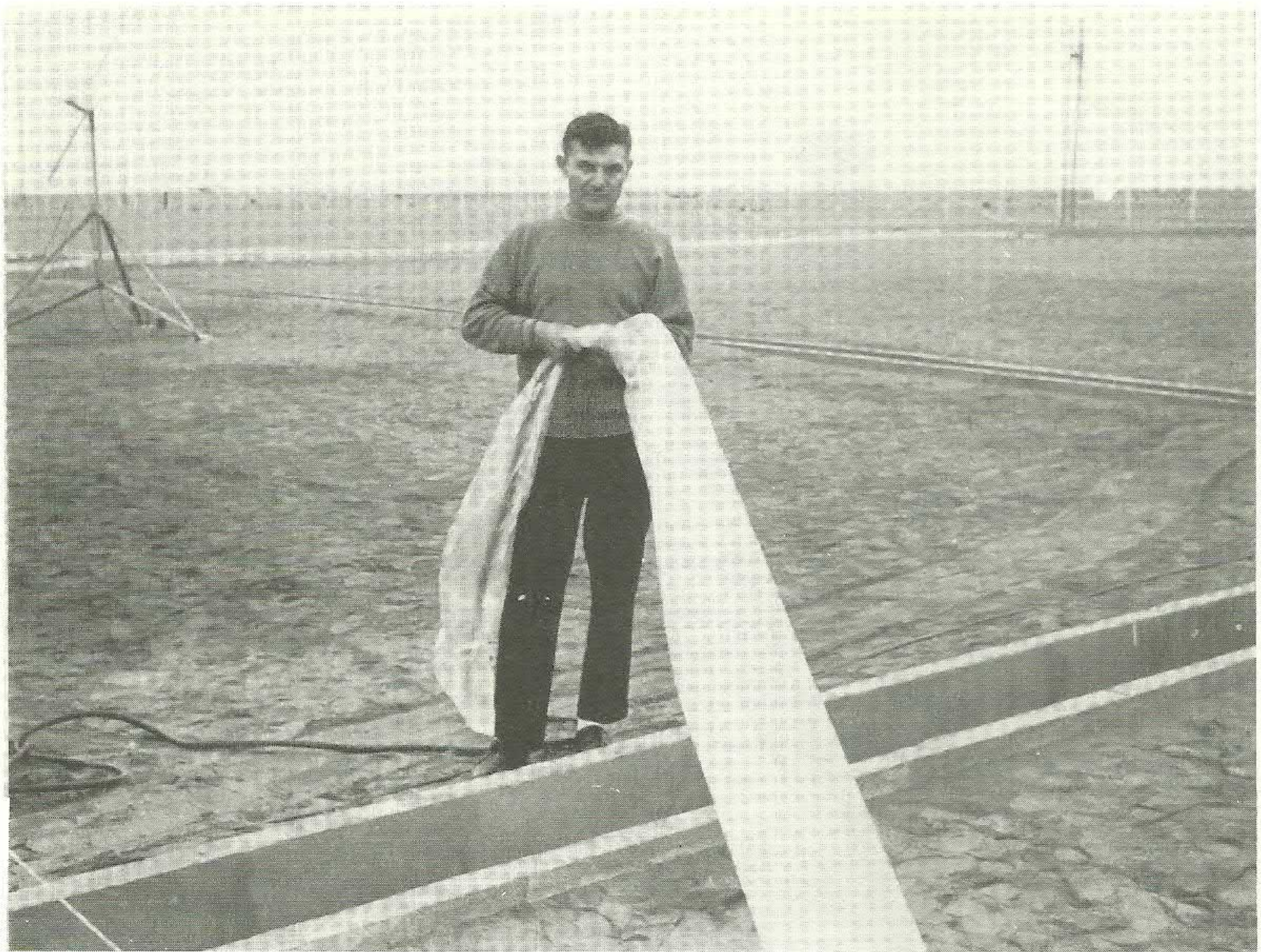


Figure 4-7. Inflation hose/diffuser is inserted into the inflation tube keeping the tube as short as is practical to minimize exposure to the ground winds. The diffuser is not secured to the inflation tube for reason of versatility.



Figure 4-8. Inflation commences after tare weight and safety lines have been attached to the balloon system at the Huch Clutch.

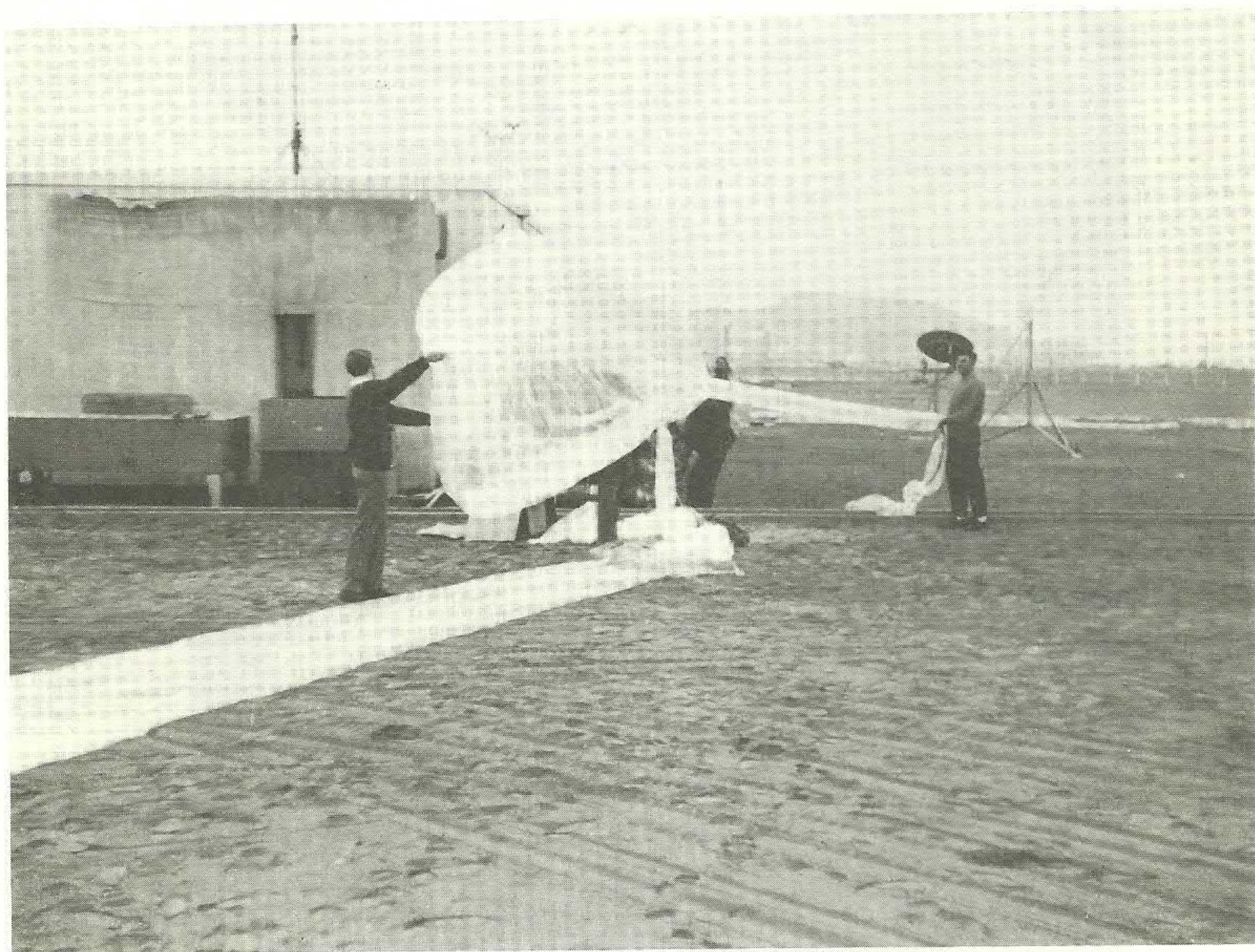


Figure 4-9. The apex is held downwind by one person until there is enough gas in the balloon to lift the bubble.

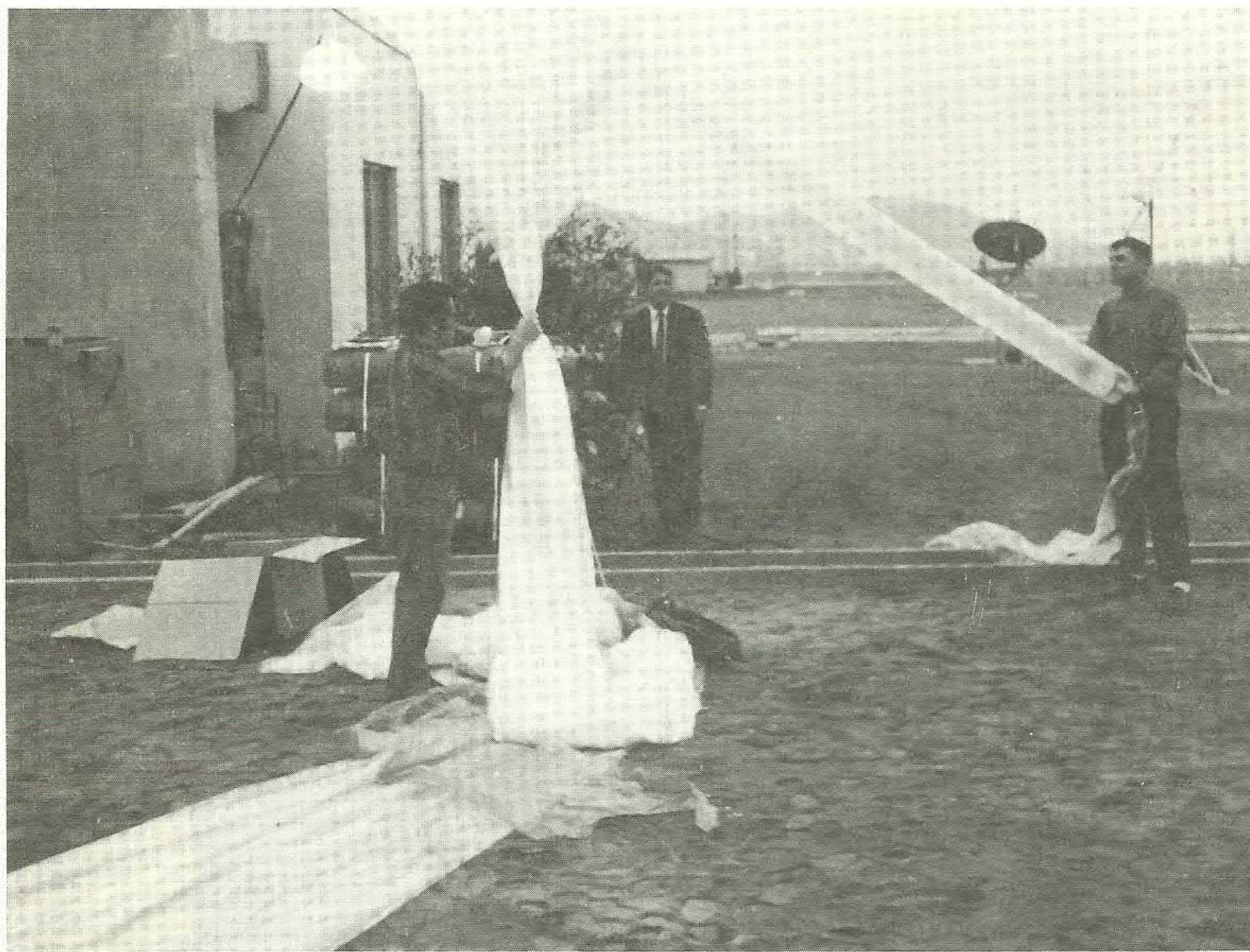


Figure 4-10. A second person holds the balloon a short distance below the inflation tube installation to maintain a tight bubble throughout inflation; this prevents sailing of the material.



Figure 4-11. Inflation nearly completed.



Figure 4-12. A weigh-off is used as a final check for sufficient gross lift.,

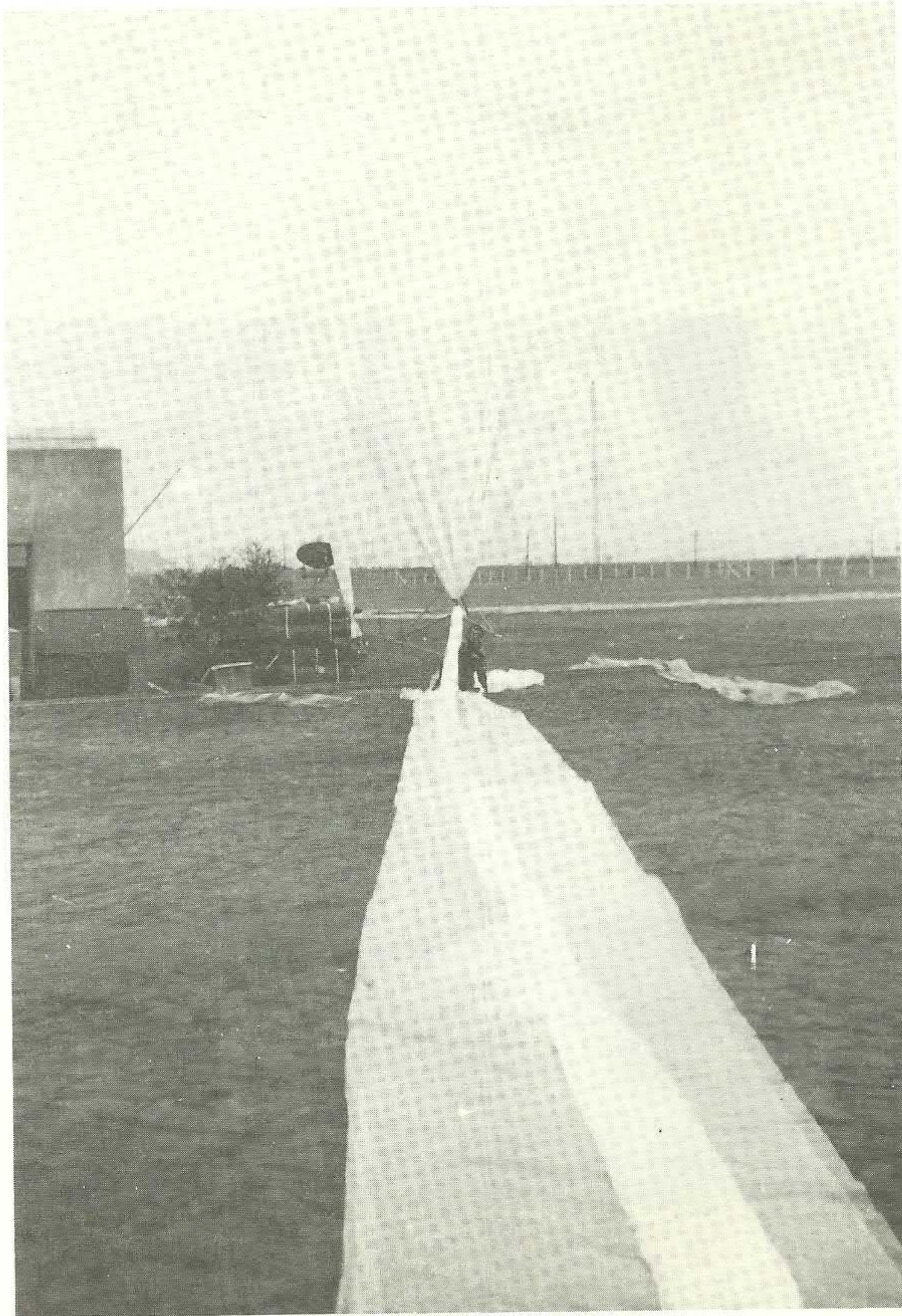


Figure 4-13. When the inflation is complete, the lower portion of the balloon is rolled out in the downwind direction on the protective ground cover. The balloon's duct is freed. Excess inflation tube is cut off and the remaining tube tied off with one overhand knot.

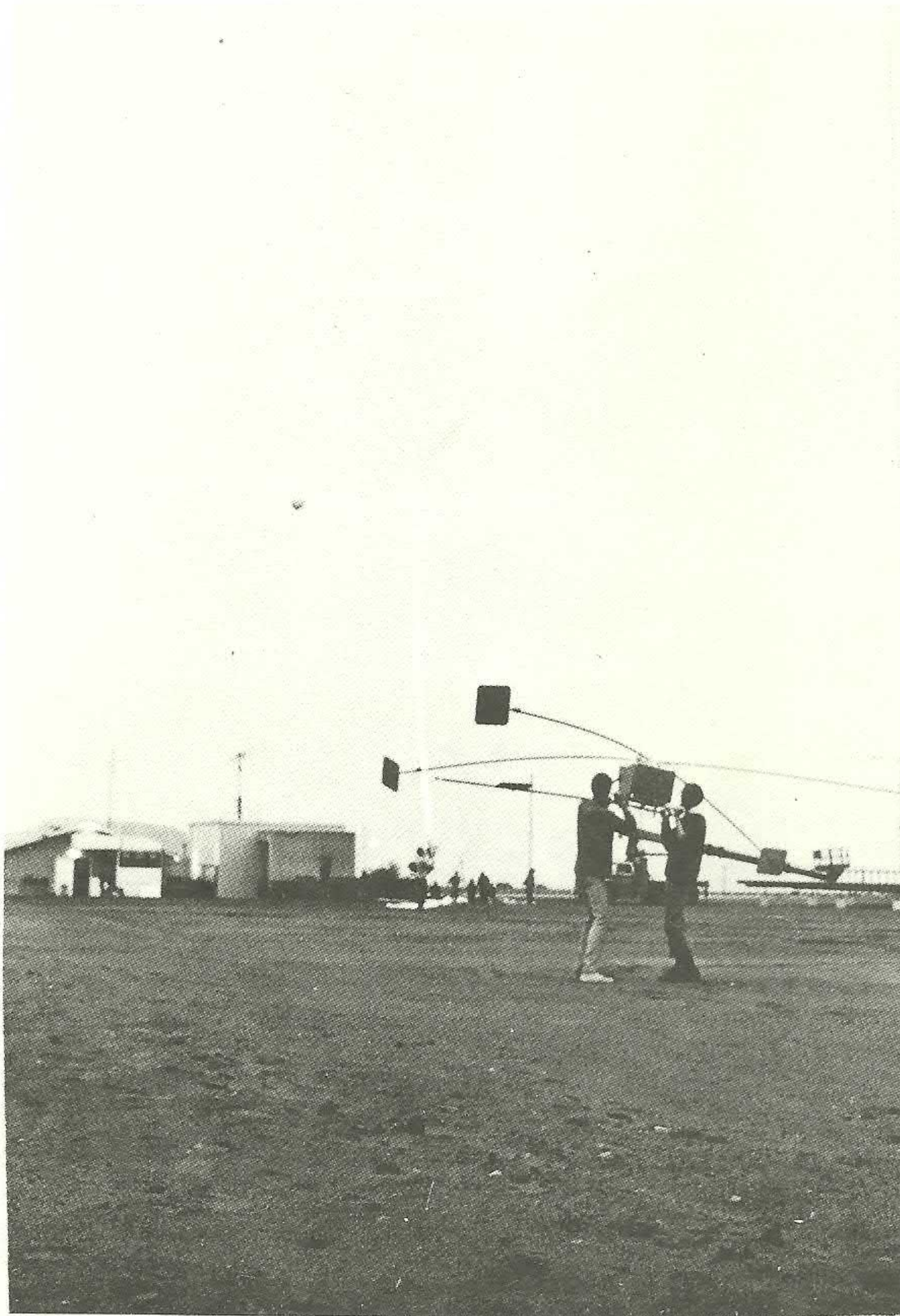


Figure 4-14. Following the attachment of the payload to the balloon, the tare weight and Huch Clutch are removed. Tension is then applied to the entire balloon system below the bubble.

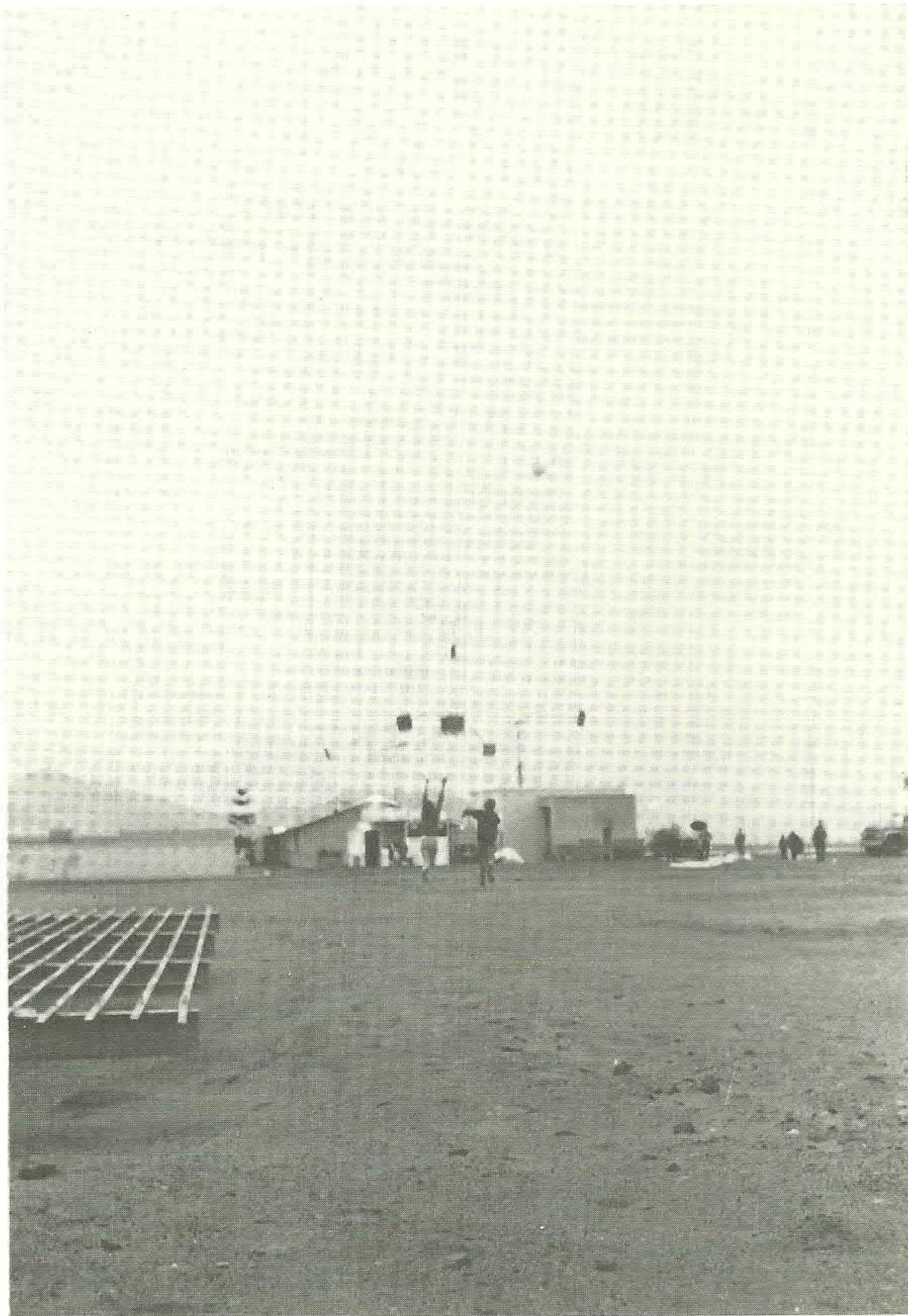


Figure 4-15. The balloon is released, and picks up the load train as it passes downwind over those holding the payload.

Appendix A. GLOSSARY OF SCIENTIFIC BALLOONING

A1. Design and Operation

A2. Electronics and Instrumentation

FOREWORD

THE SCIENTIFIC BALLOONING STANDARDS COMMITTEE IS AN INFORMAL ORGANIZATION OF THE MAJOR MANUFACTURERS AND DIRECT USERS OF SCIENTIFIC BALLOONS. PRESENTLY THE COMMITTEE MEMBERS ARE,

AIR FORCE GEOPHYSICAL RESEARCH LABORATORIES
THE SHELDON COMPANY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
OFFICE OF NAVAL RESEARCH
RAVEN INDUSTRIES, INC.
WINZEN RESEARCH, INC.

IN THE INTERESTS OF IMPROVING COMMUNICATIONS AND PRACTICES WITHIN THE INDUSTRY AND AMONG THE SCIENTIFIC COMMUNITY AS A WHOLE, THESE STANDARDS HAVE BEEN ESTABLISHED AFTER MUCH DISCUSSION BY THE MEMBERS OF THE SCIENTIFIC BALLOONING STANDARDS COMMITTEE.

IT IS NOT INTENDED THAT THE STANDARDS BE MANDATORY FOR ANYONE, BUT BECAUSE OF THE GENERAL AGREEMENT REACHED AMONG THE MEMBERS IT IS EXPECTED THAT THE STANDARDS WILL BE ADHERED TO WHENEVER PRACTICABLE.

THE VALUE OF STANDARDS ARE IN DIRECT PROPORTION TO THE BREADTH OF THEIR USE AND ACCEPTANCE. ACCORDINGLY, COMMENTS AND SUGGESTIONS FOR CORRECTIONS AND ADDITIONS ARE WELCOME. COMMUNICATIONS SHOULD BE ADDRESSED TO ONE OF THE MEMBER ORGANIZATIONS OR TO,

SCIENTIFIC BALLOONING ASSOCIATION
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
BOX 1175
FALESTINE, TEXAS 75801

GLOSSARY OF SCIENTIFIC BALLOONING

PART I

DESIGN AND OPERATIONS

A. GENERAL DEFINITIONS

TERM -----	DEFINITION -----
AERODYNAMIC FORCE	FORCE EXERTED ON THE BALLOON SYSTEM BY VIRTUE OF ITS MOTION RELATIVE TO THE SURROUNDING AIR MASS.
AERODYNAMIC SHAPE	A STREAMLINED SHAPE SIMILAR TO THAT OF A BLIMP.
AIRSHIP	AN AIRCRAFT, SELF-PROPELLED AND LIGHTER-THAN-AIR.
APEX	THAT PORTION OF A BALLOON ENCOMPASSING THE ZENITH INCLUDING THE END FITTING AND ADJACENT MATERIAL.
APPENDIX	A TUBULAR PASSAGE ON A BALLOON THROUGH WHICH EXCESS GAS IS VALVED. (SEE DUCT.)
ASCENT	THAT PORTION OF A BALLOON FLIGHT FROM LAUNCH UNTIL THE BALLOON FIRST REACHES EQUILIBRIUM.
BALLAST	DISPOSABLE MATERIAL USED TO CHANGE THE MASS OF THE SYSTEM FOR CONTROL PURPOSES (PART OF THE PAYLOAD).
BALLOON	A CONTAINER MADE OF THIN, FLEXIBLE MATERIAL FILLED WITH A GAS LESS DENSE THAN THE AMBIENT ATMOSPHERE -- INCLUDES END FITTINGS, VALVES, CONTROL WIRES AND ROPES, GAS BARRIER, GAS BARRIER REINFORCEMENTS, AND OTHER ATTACHMENTS.
BALLOON, CYLINDER	A TYPE OF NATURAL SHAPE BALLOON CONSTRUCTED FROM RECTANGULAR GORES.
BALLOON, CYLINDER-END	SEE SEMI-CYLINDER BALLOON.
BALLOON, CYLINDRICAL	ANY BALLOON DESIGNED TO HAVE A CYLINDRICAL SECTION AT ITS MAXIMUM DIAMETER.
BALLOON, LAUNCH	UPPER BALLOON OF A TANDEM SYSTEM.
BALLOON,* MAIN	THE LOWER AND USUALLY LARGER BALLOON OF A MULTIPLE CELL SYSTEM.
BALLOON, SEMI-CYLINDER	A TYPE OF NATURAL SHAPE BALLOON FABRICATED FROM GORES HAVING RECTANGULAR ENDS AND A TAILORED CENTER REGION.

TERM -----	DEFINITION -----
BALLOON, SUPERPRESSURE	A BALLOON WHICH IS DESIGNED TO HAVE POSITIVE INTERNAL PRESSURE AT THE NADIR. THE BALLOON HAS GREAT FLOATING STABILITY BY VIRTUE OF ITS NEARLY CONSTANT VOLUME.
BALLOON, TAILORED-TAPELESS	SEE SEMI-CYLINDER BALLOON.
BALLOON, TAPELESS	A BALLOON IN WHICH THE GORES HAVE THE STRENGTH NECESSARY TO CARRY THE PAYLOAD.
BALLOON, TOP	SEE LAUNCH BALLOON.
BALLOON, TOW	AN AUXILIARY BALLOON USED TO ASSIST LAUNCH AND ASCENT.
BALLOON, ZERO-PRESSURE	A BALLOON WITH ITS INTERNAL PRESSURE, AT THE NADIR, EQUAL TO THE AMBIENT ATMOSPHERIC PRESSURE. USUALLY ACCOMPLISHED WITH A DUCT WHICH IS OPEN TO THE ATMOSPHERE AT NADIR LEVEL.
BALLOON CONTROLS	ANY CONTROLS WHICH INFLUENCE THE FLIGHT PROFILE.
BASE	THAT PORTION OF A BALLOON ENCOMPASSING THE NADIR INCLUDING THE END FITTING AND ADJACENT MATERIAL.
BASE LOAD	EXTERNAL FORCE APPLIED AT THE NADIR INCLUDING THE WEIGHT OF THE FITTING AND CAPTURED ENVELOPE MATERIAL.
BLIMP	A NON-RIGID AIRSHIP.
BUBBLE	THE INFLATED PORTION OF A BALLOON.
BUBBLE MARKS	MARKINGS ON THE BALLOON USUALLY IN 5-FOOT INCREMENTS SHOWING THE GORE LENGTH AS MEASURED FROM THE APEX.
BUBBLE WEIGHT	THE ACTUAL WEIGHT OF THE BUBBLE PER UNIT GORE LENGTH. LISTED ON THE SPECIFICATION SHEET FOR USE WHEN CALCULATING THE WEIGH-OFF.
BUOYANT FORCE	WEIGHT OF THE ATMOSPHERE DISPLACED BY THE BALLOON LESS THE WEIGHT OF THE LIFTING GAS.
CANNON CUTTER	A HOLLOW TUBE THAT ENCLOSES A SQUIB AND STEEL BULLET. (ALSO CANNON LINE CUTTER.)

TERM -----	DEFINITION -----
CHAP	ONE OR MORE ADDITIONAL LAYERS OF MATERIAL BUILT INTO THE CROWN OF A BALLOON FOR REINFORCEMENT OF THE GORES.
CATAWISSA FITTING	TRADE NAME FOR FORGED-STEEL HIGH-PRESSURE UNIONS AND FITTINGS USED IN BALLOON INFLATION EQUIPMENT. NOT STANDARD.
COME ANGLE	ANGLE BETWEEN SYMMETRIC TANGENTS TO THE BALLOON SURFACE. TWICE THE PROFILE ANGLE.
CROWN	THE UPPER PORTION OF A BUBBLE, GENERALLY NO MORE THAN THE UPPER QUARTER.
CRUSH PAD	SHOCK ABSORBENT MATERIAL ATTACHED TO THE UNDERSIDE OF A GONDOLA FOR THE PURPOSE OF MINIMIZING EQUIPMENT OR PROPERTY DAMAGE DURING GONDOLA IMPACT. (USUALLY IN THE FORM OF A BLOCK OF BLOCKS OF MATERIAL.)
DENSITY ALTITUDE	THE ALTITUDE CORRESPONDING TO A GIVEN DENSITY IN A STANDARD ATMOSPHERE.
DESCENT	ANY PORTION OF FLIGHT CHARACTERIZED BY A REDUCTION IN ALTITUDE. THAT PORTION OF A BALLOON FLIGHT FROM TERMINATION, OR DEPARTURE FROM FLOAT ALTITUDE, TO THE END OF FLIGHT RESULTING FROM LANDING OR AERIAL RECOVERY.
DESCENT SYSTEM	USUALLY A PARACHUTE USED TO RETURN THE PAYLOAD TO EARTH AND THE CRUSH PAD.
DESTRUCT DEVICE	AN APPARATUS TO CAUSE DEFLATION OF THE ENVELOPE AT FLIGHT TERMINATION.
DIRIGIBLE	A RIGID AIRSHIP.
DONUT	A RIGID, PADDED RING USED TO CONTROL THE BALLOON BUBBLE DURING THE INITIAL PHASE OF INFLATION.
DUCT	ORIGINALLY USED TO DENOTE AN EXTERNAL VALVING APPENDIX EXTENDING FROM THE APEX TO THE BASE. NOW FREQUENTLY USED GENERICALLY AS A DESIGNATION FOR ANY FORM OF VALVING APPENDIX.
DYNAMOMETER	A DEVICE FOR MEASURING FORCE OR POWER. ALSO USED FOR BALLOON WEIGH-OFF.

TERM

DEFINITION

EFFECTIVE BALLOON WEIGHT	A DESIGN TERM. THE SUMMATION OF WEIGHTS OF GORES, TAPES, SEAMS, CAPS AND ANY OTHER MEMBERS WHICH HAVE A NOMINALLY UNIFORM CIRCUMFERENTIAL DISTRIBUTION.
END FITTING	A DEVICE USED AT THE BASE AND APEX OF A BALLOON TO SECURE THE GORES AND LOAD TAPES.
ENVELOPE	AN ASSEMBLY CONSISTING OF THE GORES. A TERM OFTEN USED INTERCHANGEABLY WITH BALLOON.
EXPLOSIVE BOLT	A SPECIAL THREADED RELEASE MECHANISM, USED IN COMBINATION WITH A STANDARD AN BOLT AND SPECIAL SLOTTED NUT. ACTIVATION OF THE EXPLOSIVE IN THE SHANK OF THE MECHANISM RUPTURES THE NUT PERMITTING THE SECURED PARTS TO SEPARATE. USED WHEN FAST ACTING SEPARATION IS REQUIRED.
FIFTH WHEEL	A HORIZONTAL WHEEL OR SEGMENT OF A RING CONSISTING OF TWO BANDS WHICH SLIDE ON EACH OTHER, PLACED ABOVE THE FRONT AXLE OF A CARRIAGE AND DESIGNED TO SUPPORT THE FOREPART OF THE BODY WHILE ALLOWING IT TO TURN FREELY IN A HORIZONTAL PLANE.
FILM WEIGHT	WEIGHT PER UNIT AREA OF GAS BARRIER.
FLIGHT DURATION	THE ELAPSED TIME BETWEEN LAUNCH AND THE END OF DESCENT.
FLIGHT TERMINATION	SEE TERMINATION.
FLOAT DURATION	THAT PORTION OF A BALLOON FLIGHT FROM THE TIME THE BALLOON FIRST REACHES EQUILIBRIUM UNTIL THE PAYLOAD IS SEPARATED FROM THE BALLOON OR THE BALLOON STARTS DESCENT FOR THE PURPOSE OF LANDING THE PAYLOAD.
FREE LIFT, DESIGN	SEE FREE LIFT, INITIAL.
FREE LIFT, EFFECTIVE	THE INSTANTANEOUS BUOYANT FORCE IN EXCESS OF THE GROSS LOAD.
FREE LIFT, INITIAL	ADDITIONAL LIFT INTRODUCED AT THE TIME OF INFLATION TO PROVIDE A DESIRED RATE OF ASCENT.

TERM -----	DEFINITION -----
FREE LIFT RATIO	USUALLY RATIO OF INITIAL FREE LIFT TO GROSS LOAD. FOR SUPERPRESSURE BALLOONS IT IS CONVENIENT TO USE THE RATIO OF INITIAL FREE LIFT TO GROSS LOAD PLUS GAS WEIGHT AS THIS RATIO EQUALS THE SUPERPRESSURE RATIO WHEN SUPERTEMPERATURE IS ZERO.
GAS PORT	A TYPE OF SPRING-LOADED TRAP DOOR VALVE IN THE APEX PLATE OR ELSEWHERE ON THE BALLOON TO RELEASE GAS. NOT RECLOSABLE.
GONDOLA	AN ENCLOSURE OR FRAMEWORK SUSPENDED FROM A BALLOON.
GORES	PANELS OF MATERIAL WHICH ARE ASSEMBLED TO FORM THE BALLOON ENVELOPE. USUALLY MERIDIONAL IN DIRECTION, EXTENDING FROM BASE TO APEX.
GORE CENTER LINE	A REFERENCE LINE FROM WHICH HALF-GORE WIDTH DIMENSIONS ARE MEASURED TO DEFINE A SYMMETRICAL GORE.
GORE LENGTH, RING LINE	LENGTH OF BALLOON GORE MEASURED BETWEEN REFERENCE LINES AT THE BASE AND APEX.
GORE LENGTH, THEORETICAL	LENGTH OF CURVE FROM NADIR TO ZENITH DESCRIBING THE INFLATED BALLOON SHAPE.
GORE STATIONS	LOCATIONS ON THE GORE CENTER LINE, MEASURED FROM A REFERENCE AT THE BASE.
GROSS INFLATION	TOTAL BUOYANT FORCE AT LAUNCH (GROSS LOAD PLUS INITIAL FREE LIFT).
GROSS LOAD	TOTAL AIRBORNE WEIGHT, EXCLUSIVE OF LIFTING GAS. EQUALS BALLOON WEIGHT PLUS PAYLOAD WEIGHT.
GROSS WEIGHT	SEE GROSS LOAD.
HORSE COLLAR	SIMILAR TO THE DONUT IN FORM AND USE EXCEPT BEING MORE OF A FLEXIBLE LOOP.
HUCK CLUTCH	A POLY AND CLOTH CHOKER INSTALLED AT THE BASE OF A BUBBLE USED IN BALLOON WEIGH-OFF. ALSO USED FOR LAUNCHING LIGHT PAYLOADS (UP TO 150-175 LB GROSS INFLATION). NAMED AFTER MR. W. HUCK.

TERM

DEFINITION

INFLATION TUBE A FILLER TUBE, COMMONLY OF MATERIAL SIMILAR TO THE BALLOON GORES AND USUALLY EXTENDING INTO THE PRE-LAUNCH BUBBLE PORTION OF THE BALLOON.

LAUNCH THE OPERATION OF INFLATING THE BALLOON AND GETTING IT AIRBORNE. SPECIFICALLY THE TIME OF RELEASE OF THE PAYLOAD DURING THE LAUNCH OPERATION.

LAUNCH, ANCHOR LINE A METHOD WHICH UTILIZES A RESTRAINING CABLE BETWEEN THE PARACHUTE BASE AND AN ANCHOR VEHICLE. THE ANCHOR LINE IS CUT AWAY AT THE PARACHUTE BASE, USUALLY BY A PYROTECHNIC, AFTER THE PAYLOAD IS AIRBORNE.

LAUNCH COLLAR A RESTRAINING MEMBER WHICH ENCIRCLES A BALLOON BELOW THE BUBBLE. USED TO ASSIST DURING INFLATION AND LAUNCH. (SEE DONUT, HORSE COLLAR.)

LAUNCH, DYNAMIC (UPWIND) IN THIS PROCEDURE, THE BALLOON IS INITIALLY POSITIONED UPWIND OF THE PAYLOAD. THE PAYLOAD IS RESTRAINED ON A MOVABLE LAUNCH VEHICLE AND THE BUBBLE IS RESTRAINED BY A LARGE INFLATION SPOOL. AFTER INFLATION IS COMPLETE AND ALL SYSTEMS ARE READY, WITH PERMISSION FROM THE LAUNCH DIRECTOR, THE BUBBLE IS RELEASED. AS IT RISES, THE WIND CARRIES IT TOWARD THE LAUNCH VEHICLE. THE LAUNCH VEHICLE THEN MOVES TO COMPENSATE FOR VARIABLE WIND SPEED AND DIRECTION. WHEN THE FLIGHT TRAIN IS DIRECTLY ABOVE THE PAYLOAD AND POSITIONED TO GIVE AS SMALL A LAUNCH FORCE AS POSSIBLE, THE PAYLOAD IS RELEASED FROM THE LAUNCH VEHICLE.

LAUNCH, DYNAMIC (DOWNWIND) THE DIFFERENCE BETWEEN THIS TECHNIQUE AND THE UPWIND METHOD IS THAT THE BALLOON IS INITIALLY POSITIONED DOWNWIND OF THE PAYLOAD AND THE LAUNCH VEHICLE CHASES AFTER THE RELEASED BALLOON RATHER THAN MOVING TO INTERCEPT IT.

LAUNCH, STATIC A LAUNCH THAT IS ACCOMPLISHED THROUGH COMPLETE ERECTION OF THE SYSTEM ABOVE A FIXED POINT.

LAUNCH, STONEHENGE A FORM OF STATIC LAUNCH OF A TANDEM BALLOON SYSTEM. A MAINSTAY IS USED TO ERECT THE TOP AND MAIN BALLOONS. A PAIR OF SHORT ANCHOR LINES RESTRAIN THE BALLOON SO THAT THERE IS NO TENSION ON THE SCIENTIFIC PAYLOAD. PRIOR TO RELEASE OF THE ANCHOR LINES, THE SYSTEM CAN BE REORIENTED TO ACCOMMODATE WIND DIRECTION CHANGES. DESIGNED TO FACILITATE LAUNCHING HEAVY-LOAD SYSTEMS.

TERM -----	DEFINITION -----
LIFT-OFF	THE TIME OF LAUNCH.
LOAD TAPE	MERIDIONAL MEMBER ATTACHED TO A BALLOON TO PROVIDE ADDITIONAL STRENGTH NECESSARY TO CARRY THE PAYLOAD. USUALLY ATTACHED AT GORE SEAMS.
MAGNAHELIC GAUGE	TRADE NAME FOR A LOW PRESSURE GAS PRESSURE GAUGE USUALLY CALIBRATED IN INCHES OF WATER.
MDF	MILD DETONATING FUSE A SMALL-DIAMETER DETONATING CORD CAPABLE OF TRANSFERRING A DETONATION FROM ONE POINT TO ANOTHER WITHOUT DAMAGE TO ADJACENT EQUIPMENT. CONTAINS A CONTINUOUS CORE OF A FEW GRAINS PER FOOT OF HIGH EXPLOSIVE.
NADIR	LOWER THEORETICAL CONFLUENCE POINT OF THE ENVELOPE.
NATURAL SHAPE	THE SHAPE WHICH A BALLOON TAKES IF IT HAS CIRCUMFERENTIAL STRESS EQUAL TO ZERO EVERYWHERE.
NOLARO	TRADE NAME FOR CABLE WITH A NUMBER OF TWISTED FILAMENTS LAID PARALLEL AND COVERED WITH A JACKET (NO-LAY-ROPE).
PAYLOAD	WEIGHT OF THE ENTIRE BALLOON FLIGHT SYSTEM EXCLUSIVE OF THE WEIGHT OF THE BALLOON.
PILLOW BALLOON	TRADE NAME (REG. TM RAVEN IND., INC.) FOR A SIMPLE BALLOON MADE BY CLOSING THE TWO ENDS OF A PIECE OF TUBULAR MATERIAL WITH STRAIGHT, PARALLEL SEALS.
PRESSURE ALTITUDE	THE ALTITUDE CORRESPONDING TO A GIVEN PRESSURE IN A STANDARD ATMOSPHERE.
PRESSURIZATION ALTITUDE	THE ALTITUDE AT WHICH THE ENVELOPE FIRST BECOMES FULL.
PRIMACORD	TRADEMARK FOR A LINEAR DETONATING CORD CONTAINING CORE LOADS OF 40 OR MORE GRAINS PER FOOT OF HIGH EXPLOSIVE.
PROFILE ANGLE	ANGLE BETWEEN A TANGENT TO THE BALLOON SURFACE AND THE CENTERLINE, MEASURED IN A PLANE CONTAINING THE CENTER LINE.
SAFETY FACTOR	THE RATIO OF THE FAILURE, OR YIELD, STRESS TO THE DESIGN STRESS.

TERM

DEFINITION

SAIL	AN UNDESIRABLE CONDITION WHICH OCCURS WHEN THE WIND FORCES SLACK BALLOON MATERIAL INTO A SPINNAKER-LIKE CONFIGURATION.
SCIENTIFIC LOAD	EQUIPMENT OF SCIENTIST OR EXPERIMENTER -- PART OF THE PAYLOAD.
SIGMA	A DESIGN PARAMETER WHICH GOVERNS THE BALLOON SHAPE. A FUNCTION OF THE FILM WEIGHT, PAYLOAD AND SPECIFIC BUOYANCY.
SLEEVE, PACKING	A TUBE OR WRAPPER WHICH EXTENDS THE FULL LENGTH OF THE BALLOON AND PROVIDES PROTECTION DURING PACKAGING AND LAYING OUT THE BALLOON.
SLEEVE, REEFING	A TUBULAR MEMBER INSTALLED ON A BALLOON FROM BASE TO PRE-LAUNCH BUBBLE. USED TO CONTROL TEMPORARILY-EXCESS MATERIAL DURING ASCENT.
SPECIFIC BUOYANCY	UNIT LIFT OF THE INFLATION GAS, NUMERICAL DIFFERENCE BETWEEN THE SPECIFIC WEIGHTS OF THE SUPPORTING FLUID AND THE INFLATING FLUID.
SQUIB	ANY OF VARIOUS SMALL SIZE ELECTRICALLY DETONATED PYRO-TECHNICS OR EXPLOSIVES.
STAY, AUXILARY	A SAFETY CABLE OR LINE USED TO CONTROL AND DAMPEN LATERAL EXCURSIONS OF AN ERECTED BALLOON.
STAY, MAIN	A CABLE IN THE PLANE OF THE WIND USED TO CONTROL AND ERECT THE BUBBLE PRIOR TO LAUNCH.
SUPERPRESSURE	INTERNAL BALLOON PRESSURE IN EXCESS OF AMBIENT PRESSURE.
SUPERTEMPERATURE	BALLOON INTERNAL TEMPERATURE IN EXCESS OF AMBIENT TEMPERATURE. (INCORRECTLY CALLED SUPERHEAT.)
STANDARD ATMOSPHERE	A DEFINED RELATIONSHIP BETWEEN ALTITUDE AND ATMOSPHERIC PARAMETERS. (U.S. STANDARD ATMOSPHERE, 1962, IS MOST COMMONLY USED. SPECIAL STANDARD ATMOSPHERES MAY BE USED AT SPECIFIC LOCATIONS AND TIMES.)
SUPPORTED LOAD	SEE PAYLOAD.
SUSPENDED LOAD	THAT PART OF THE PAYLOAD CARRIED AT THE BASE OF THE BALLOON.

TERM -----	DEFINITION -----
SUSPENSION POINT	ATTACHMENT POINT FOR THE PAYLOAD, USUALLY INCORPORATED INTO THE BASE END FITTING.
TANDEM SYSTEM	A TWO-BALLOON SYSTEM HAVING AN UPPER BALLOON WHICH CONTAINS ALL GAS AT LAUNCH AND A LOWER BALLOON WHICH INFLATES FROM THE UPPER BALLOON DURING ASCENT.
TAPE	SEE LOAD TAPE.
TENNEY RELEASE	AN EXPLOSIVELY RELEASED CLEVIS DESIGNED BY MR. TENNEY.
TERMINATION	THE TIME OF SEPARATION OF THE PAYLOAD FROM THE BALLOON VEHICLE.
TERMINATION DEVICE	ANY ONE OF SEVERAL FITTINGS USED TO SEPARATE THE BALLOON AND PAYLOAD.
TETROON	A BALLOON ENVELOPE CONSTRUCTED AS A REGULAR TETRAHEDRON.
THEORETICAL CEILING	THE CALCULATED ALTITUDE AT WHICH A BALLOON SHOULD FLOAT BASED ON ITS CALCULATED FLIGHT VOLUME, AND GROSS LOAD, ASSUMING ZERO SUPER-TEMPERATURE AND A REFERENCE ATMOSPHERE.
THERMODYNAMIC DRAG	A CHANGE IN BUOYANT FORCE DUE TO INEQUALITY OF THE EFFECTIVE INTERNAL TEMPERATURE AND THE AMBIENT TEMPERATURE.
TOP LOAD	THAT PART OF THE PAYLOAD WHICH IS LOCATED AT THE APEX OF A BALLOON.
TRANSFER DUCT	A FITTING THROUGH WHICH GAS PASSES BETWEEN THE TWO CELLS OF A TANDEM SYSTEM.
VALVE SYSTEM	A SYSTEM OTHER THAN THE DUCTS FOR RELEASING LIFTING GAS.
WEIGH-OFF	THE MEASUREMENT OF INITIAL FREE LIFT, WITH SUFFICIENT TIME WEIGH-OFF CAN BE USED TO CHECK ENVELOPE INTEGRITY.
ZENITH	UPPER THEORETICAL CONFLUENCE POINT OF THE ENVELOPE.

B. SYMBOLS

SYMBOL -----	NAME -----	DEFINITION -----	DIMENSION -----
A	AREA	BALLOON THEORETICAL OR CONSTRUCTED SUR- FACE AREA	L ²
B	BUOYANT FORCE	= bv	ML/T ²
D	AERODYNAMIC DRAG	COMPONENT OF AERODYNAMIC FORCE OPPOSITE TO THE DIRECTION OF MOTION	ML/T ²
D	THERMODYNAMIC DRAG	CHANGE IN BUOYANT FORCE DUE TO IN- EQUALITY OF EFFECTIVE TEMPERATURE OF INTERNAL AND AMBIENT GAS	ML/T ²
F	FREE LIFT	BUOYANT FORCE MINUS GROSS LOAD	ML/T ²
F_n	BASE LOAD	EXTERNAL FORCE AT NADIR INCLUDING WEIGHT OF FITTING AND CAPTURED MATERIAL	ML/T ²
F_z	APEX LOAD	EXTERNAL FORCE AT ZENITH INCLUDING WEIGHT OF FITTING AND CAPTURED MATERIAL	ML/T ²
G	GORE WIDTH	= $2\pi r/n$	L
L	AERODYNAMIC LIFT	COMPONENT OF AERODYNAMIC FORCE PERPEN- DICULAR TO THE DIRECTION OF MOTION	ML/T ²
M	MOLECULAR WEIGHT		---
N	NUMBER OF GORES		---

SYMBOL	NAME	DEFINITION	DIMENSION
R	MAXIMUM RADIUS	RADIUS AT BALLOON EQUATOR	L
R*	UNIVERSAL GAS CONSTANT		L ² /T ²
S	GORE LENGTH		L
T	FILM LOAD	SUMMATION OF ALL MERIDIONAL FORCES, $= 2\pi r \sigma_m$ IN TAPELESS BALLOON	ML/T ²
T	TEMPERATURE		---
V	VOLUME	VOLUME OF THE ENCLOSED GAS	L ³
W _b	BALLOON WEIGHT, EFFECTIVE	TOTAL WEIGHT OF BALLOON, INCLUDING ALL ACCESSORIES AND ATTACHMENTS	ML/T ²
W _e	BALLOON WEIGHT, EFFECTIVE		ML/T ²
W _g	GROSS LOAD	TOTAL AIRBORNE WEIGHT EXCLUSIVE OF LIFT- ING GAS, EQUALS BALLOON WEIGHT PLUS PAYLOAD.	ML/T ²
W _p	PAYLOAD	ALL WEIGHT CARRIED BY A BALLOON	ML/T ²
W _s	BALLAST WEIGHT		ML/T ²
Z	NOMINAL HEIGHT	AXIAL LENGTH FROM NAQIR TO ZENITH	L

SYMBOL	NAME	DEFINITION	DIMENSION
a	SUPERPRESSURE HEAD	PRESSURE HEAD AT NADIR	L
$\bar{a}$	PRESSURE HEAD HEIGHT RATIO	$= a/\lambda$	---
b	SPECIFIC BUOYANCY	NUMERICAL DIFFERENCE BETWEEN SPECIFIC WEIGHT OF SUPPORTING FLUID AND INFLATING FLUID	M/L ² T ²
d	DESIGN VALUE	SUBSCRIPT USED TO DENOTE DESIGN VALUE	---
f	FREE LIFT RATIO	RATIO OF FREE LIFT TO GROSS LOAD	---
m	MASS		M
o	---	SUBSCRIPT USED TO DENOTE SEA LEVEL VALUE	---
p	PRESSURE	GAS FORCE PER UNIT AREA	M/LT ²

SYMBOL	NAME	DEFINITION	DIMENSION
r	RADIUS	RADIAL POINT ON SURFACE MEASURED NORMAL TO BALLOON CENTER LINE	L
$\bar{r}$	BALLOON RADIUS RATIO	$= r/\lambda$	---
s	GORE STATION	GORE COORDINATE OF POINT ON SURFACE MEASURED ALONG THE GORE CENTERLINE FROM THE NADIR	L
$\bar{s}$	BALLOON LENGTH RATIO	$= s/\lambda$	---
t	FILM THICKNESS		L
v	VERTICAL VELOCITY	RATE OF ASCENT OR DESCENT	L/T
w	FILM WEIGHT	WEIGHT PER UNIT AREA OF GAS BARRIER	M/LT ²
z	HEIGHT	HEIGHT COORDINATE OF A POINT ON THE BALLOON SURFACE MEASURED PARALLEL TO BALLOON CENTER LINE	L
$\bar{z}$	BALLOON HEIGHT RATIO	$= z/\lambda$	---

TERM		DEFINITION	
SYMBOL	NAME	DEFINITION	DIMENSION
Δp	SUPERPRESSURE	BALLOON INTERNAL PRESSURE IN EXCESS OF AMBIENT	M/LT ²
ΔT	SUPERTEMPERATURE	BALLOON INTERNAL TEMPERATURE IN EXCESS OF AMBIENT	---
Σ	SHAPE PARAMETER	FILM WEIGHT FACTOR, $= (2\pi)^{1/3} w_b / \lambda$	---

SYMBOL	NAME	DEFINITION	DIMENSION
β	BUOYANCY RATIO	RATIO OF BUOYANCY AT SPECIFIC ALTITUDE TO BUOYANCY AT DESIGN ALTITUDE $= b/b_d$	---
δ	DIFFUSION	LIFT LOSS PER TIME PERIOD	ML/T ³
ϵ	STRAIN	ELONGATION IN LENGTH/LENGTH	---
θ	PROFILE ANGLE	ANGLE BETWEEN TANGENT TO BALLOON SURFACE AND BALLOON CENTER LINE	---
λ	CHARACTERISTIC LENGTH	$= (w_p/b)^{1/3}$	L
ρ	DENSITY	MASS DENSITY	M/L ³
σ	DENSITY RATIO	$= \rho/\rho_o$	---
σ_c	STRESS, CIRCUMFERENTIAL	STRESS NORMAL TO MERIDIONAL STRESS	M/T ²
σ_m	STRESS, MERIDIONAL	STRESS IN PLANE CONTAINING AXIS OF ROTATIONAL SYMMETRY	M/T ²
ϕ	CONE ANGLE	TOTAL ANGLE BETWEEN SYMMETRIC TANGENTS TO BALLOON SURFACE, $= 2\theta$	---

GLOSSARY OF SCIENTIFIC BALLOONING

PART II

ELECTRONICS AND INSTRUMENTATION

THE SCIENTIFIC BALLOONING STANDARDS COMMITTEE HAS ADOPTED
AS A STANDARD REFERENCE.

A GLOSSARY OF RANGE TERMINOLOGY
DOCUMENT 104-64
REVISED 1963

AVAILABLE FROM:

SECRETARIAT
RANGE COMMANDERS COUNCIL
ATTN. STEWS-SA-R
WHITE SANDS MISSILE RANGE
NEW MEXICO 88002

THE FOLLOWING ARE ADDITIONS PECULIAR TO ELECTRONICS AND
INSTRUMENTATION IN THE FIELD OF SCIENTIFIC BALLOONING.

TERM

DEFINITION

ALTITUDE SWITCH	A PRESSURE SWITCH WHICH WILL ACTUATE AT A PRESSURE CORRESPONDING TO A PREDETERMINED ALTITUDE BASED ON A STANDARD ATMOSPHERE.
BEACON-BAROCODED	A DEVICE WHICH GENERATES A RADIO FREQUENCY SIGNAL TO BE USED AS A BEACON SIGNAL BY A TRACKING AIRCRAFT. THE RADIO SIGNAL IS MODULATED WITH CODE WHICH REPRESENTS AMBIENT PRESSURE AS DETERMINED BY AN ANEROID PRESSURE GAGE.
COMMUNICATIONS REPEATER	A BALLOON-BORNE COMMUNICATIONS SIGNAL REPEATER WHICH EXTENDS THE RANGE OF COMMUNICATION OF FIXED OR MOBILE STATIONS BEYOND THE RADIO HORIZON.
COMMAND CHANNEL	A PARTICULAR DIGITAL CODE OR TONE COMBINATION WHICH IS ASSIGNED TO PERFORM A PARTICULAR COMMAND FUNCTION.
COMMAND DECODER	BALLOON-BORNE ELECTRONIC EQUIPMENT WHICH RECOGNIZES DIGITAL COMMAND CODES AND ACTUATES THE COMMAND FUNCTIONS.
COMMAND ENCODER	GROUND-BASED ELECTRONIC EQUIPMENT WHICH GENERATES THE DIGITAL CODE FOR TRANSMITTING A PCM COMMAND SIGNAL.
COMMAND VERIFICATION	TO DETERMINE, BY MEANS OF TELEMETRY, THAT A COMMAND-CONTROL SIGNAL HAS BEEN RECEIVED AT THE BALLOON.
ENVIRONMENT RECORDER	A FLIGHT RECORDER FOR MEASURING ENVIRONMENTAL PRESSURE, TEMPERATURE AND TIME ON PHOTOGRAPHIC FILM OR MAGNETIC RECORDING TAPE.
ENVIRONMENTAL CHECKOUT	PREFLIGHT CHECKOUT OF ELECTRONIC EQUIPMENT UNDER EXTREME ENVIRONMENTAL CONDITIONS.
FLIGHT PACKAGE	AN ASSEMBLY OF EQUIPMENT PREPARED FOR FLIGHT ON A BALLOON.
FLIGHT PROGRAMMER	A TIMER USED TO ACTUATE CERTAIN FUNCTIONS DURING A BALLOON FLIGHT.

TERM

DEFINITION

FLIGHT SUPPORT ELECTRONICS	A FLIGHT PACKAGE CONTAINING ELECTRONIC EQUIPMENT NECESSARY TO THE FLIGHT OTHER THAN THE SCIENTIFIC EQUIPMENT. SOME OF THE FLIGHT SUPPORT EQUIPMENT, SUCH AS TELEMETRY AND COMMAND-CONTROL, MAY BE USED IN CONJUNCTION WITH THE SCIENTIFIC EXPERIMENT.
FUNCTION VERIFICATION	THE DETERMINATION BY MEANS OF TELEMETRY THAT A COMMAND AND CONTROL SIGNAL HAS ACCOMPLISHED A SPECIFIED FUNCTION.
GROUND STATION	A GROUND-BASED STATION CONTAINING ELECTRONIC EQUIPMENT NECESSARY TO SUPPORT EITHER THE BALLOON FLIGHT OR THE SCIENTIFIC EQUIPMENT OR BOTH.
LATCHING COMMAND RELAY	A RELAY WHICH IS ACTUATED PERMANENTLY AFTER THE RECEPTION OF A COMMAND SIGNAL ON A PARTICULAR CHANNEL. A COMMAND SIGNAL ON ANOTHER CHANNEL IS REQUIRED TO ACTUATE THE RELAY INTO ITS OTHER STATE.
LAUNCH PAD CHECKOUT	CHECKOUT OF FLIGHT SUPPORT ELECTRONICS ON THE LAUNCH PAD IMMEDIATELY PRIOR TO FLIGHT.
MOMENTARY COMMAND RELAY	A RELAY WHICH IS MOMENTARILY ACTUATED AFTER RECEPTION OF A COMMAND SIGNAL.
PCM COMMAND-CONTROL	A COMMAND-CONTROL SYSTEM USING PULSE-CODE OR DIGITAL TECHNIQUES TO ESTABLISH COMMAND CHANNELS.
PHOTOBAROGRAPH	AN ON-BOARD DEVICE FOR RECORDING AMBIENT AIR PRESSURES AS A FUNCTION OF TIME FROM AN ANEROID PRESSURE GAGE ON PHOTOGRAPHIC FILM.
PRELAUNCH CHECKOUT	CHECKOUT OF FLIGHT SUPPORT ELECTRONICS WHICH HAVE BEEN INTEGRATED WITH SCIENTIFIC EQUIPMENT SOMETIME PRIOR TO LAUNCH PREPARATIONS.
PRESSURE SWITCH	A SWITCH WHICH IS ACTUATED UNDER PREDETERMINED PRESSURE CONDITIONS.

TERM -----	DEFINITION -----
PRINT-OUT	THE PRINTED OUTPUT OF A TELEMETRY OR COMPUTER SYSTEM.
ROTATOR	A POWERED DEVICE WHICH CAUSES THE GONDOLA TO ROTATE WITH RESPECT TO THE BALLOON.
SLIP RINGS	AN ASSEMBLY PLACED IN THE BALLOON FLIGHT TRAIN WHICH ALLOWS FREE ROTATION OF THE BALLOON PAYLOAD WITH RESPECT TO THE BALLOON WHILE RETAINING ELECTRICAL CIRCUIT CONTINUITY THROUGH THE ASSEMBLY.
STABLE PLATFORM	A BALLOON-BORNE ASSEMBLY FOR THE SCIENTIFIC EQUIPMENT WHICH RETAINS ITS ORIENTATION WITH RESPECT TO A FIXED REFERENCE IN ONE OR MORE OF ITS AXES.
TERMINATION PACKAGE	A FLIGHT PACKAGE MOUNTED IN THE FLIGHT TRAIN ABOVE THE PARACHUTE AND USED SOLELY TO TERMINATE THE BALLOON FLIGHT.
TERMINATION TIMER	A TIMER USED FOR FLIGHT TERMINATION, USUALLY SUPPLEMENTARY TO TERMINATION BY COMMAND.
TIMER ADVANCE	MOVING A TIMER FORWARD IN TIME SUCH AS TO REDUCE THE AMOUNT OF TIME UNTIL THE PRESET TIMED EVENT OCCURS.
TIMER RETARD	MOVING A TIMER BACKWARD IN TIME SUCH AS TO INCREASE THE AMOUNT OF TIME UNTIL THE PRESET TIMED EVENT OCCURS.
TONE COMMAND-CONTROL	A COMMAND-CONTROL SYSTEM USING AUDIO TONES, SINGLY OR IN COMBINATION, TO ESTABLISH COMMAND CHANNELS.
TOP PACKAGE	A FLIGHT PACKAGE MOUNTED ON TOP OF A BALLOON.
WINDOW	THE PERIOD OF TIME AS DETERMINED BY THE SCIENTIFIC ENVIRONMENT DURING WHICH THE SCIENTIST CAN EXPECT TO OBTAIN SCIENTIFIC DATA.

Appendix B. SAFETY STANDARDS FOR SCIENTIFIC BALLOONING

SAFETY STANDARDS FOR SCIENTIFIC BALLOONING

General

Safety is the responsibility of each individual. The Manager, however, is responsible for the establishment of safety standards and regulations, and for the elimination or minimization of any potential hazards within the area of operations. All personnel will observe the safety standards which are established by this Manual to prevent injury to persons and damage to equipment and property. Each Manager will enforce the safety regulations, and to assist him a Safety Officer should be appointed for all flights. The Safety Officer should have full authority to enforce safety regulations and to stop the proceedings at any time when, in his judgement, either personnel or equipment are endangered. The Safety Officer should give the final clearance for launch and be prepared to terminate the flight if unusual or dangerous conditions occur in the first few minutes after launch.

All organizations should strictly comply with FAA Regulations. Even flights which do not come under FAA Regulations, such as six and twelve-pound payloads, should be flown with appropriate cut-down and destruct devices.

General Safety areas include the following:

Health hazards, with particular attention to adequate ventilation by clean, moving air, cooling for comfort and efficiency; adequate illumination for protection from eye fatigue; protection against atmospheric contaminants; protection against skin contaminants; protection against noise hazards; personal hygiene; and good housekeeping.

Fire prevention, to include proper storage of and work activities with inflammable liquids, gases and chemicals; smoking in unsafe and/or unauthorized areas; open flames in heating equipment or other circumstances; electrical fuses and equipment; storage containers and good housekeeping to avoid clutter.

Aircraft flight lines and parking ramps will be avoided by vehicles except when absolutely necessary (i.e., off-loading of aircraft). Under no circumstances will personnel violate operating standards as relates to the restriction of vehicles from aircraft operating-or-parking areas.

Motor vehicle operations, to include control and dispatch of vehicles; use of licensed operators for driving vehicles; safe driving practices; cargo loading (with attention to maximum loads, load distribution, and avoidance of over-hanging loads); personnel loading (with particular attention to avoid overloading the vehicle cab); to

insure entry or departure from the vehicle only while it is standing still; and prohibition against riding on any part of the vehicle not designed to carry passengers; and proper preventative maintenance of the vehicle.

Safety of People during Launch

1. Hard hats should be worn by all personnel.
2. Hard-toe safety shoes should be worn during rigging and on the flight line.
3. All exposed rings, watches, zippers, buttons and other exposed objects should not be worn during rigging or on the flight line.
4. Ear defenders should be worn by all helium handlers, i.e., hose, gauge, bubble, and truck driver.
5. Seat belts and/or body restraining devices should be available and worn by all personnel riding the launch vehicle.
6. An individual should stand by the helium source gauge at all times to shut off the helium in case of hose-burst or other emergency.
7. After start of inflation, no person should be permitted to straddle or step over the balloon train.
8. A safety line with a red marker should be used at critical points on the balloon train to prevent injury or damage in case of connector breakage.
9. Explosive devices which tend to separate the bottom end fittings during the act of balloon destruction shall be banned. End fittings should not be severed in such a manner that they can free-fall.
10. All squib cases should be grounded to one squib lead and electrical security should be guaranteed during connection. Personnel should be properly trained in the storage, transportation and proper handling of squibs.
11. The length of time that recovery personnel are required to be on duty should be limited to a reasonable number of hours. People who are required to be on duty for more than 18 hours lose efficiency and present a danger both in

the air and on the highway.

Safety During Recovery

1. Recovery aircraft should be equipped with a proper emergency kit to include first aid and survival items.
2. All tracking and recovery aircraft should be manned by two qualified pilots to insure aerial safety.
3. All FAA Regulations pertinent to aircraft operations should be strictly complied with.
4. There will be no smoking in or within 50 feet of aircraft on the ground.
5. All personnel working around aircraft will familiarize themselves with the locations of fire extinguishers within the aircraft.
6. Aircraft fuses or circuit breakers will be replaced or reset only with the consent of qualified personnel.
7. There will be no smoking during ground operations, take-off, landing, oxygen use, or any time the No Smoking sign is lighted.
8. Safety belts will be worn during all take-offs and landings and at such other times as instructed by the pilot.
9. Ground recovery vehicles should be equipped with proper first aid kits, fire extinguishers, anti-corrosive liquid (water) and protective gloves for battery handling, seat belts and shoulder harness, flares and other emergency road equipment.
10. All ground recovery vehicles should be manned by a minimum of two people.
11. Legal speed limits should be observed at all times.
12. A warning notice to the general public concerning electrical and detonable items should be posted on all packages.
13. Procedures for handling equipment landing on-or-across power lines and suspected power lines: Basically, all lines should be suspect, the area should be quarantined, and the nearest power company called for assistance.

Appendix C. AVIATION REGULATIONS

- C1. Part 101, U.S. Federal Aviation Regulations
- C2. Check List and Information. HIBAL NOTICES
- C3. Derelict Procedures
- C4. International Civil Organization
Questionnaire for Evaluation of
Balloon Flight Safety

Federal Aviation Regulations

MAY 7 1974

PART 101

Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons

Published March 1974

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION



Introductory Note

Part 101 is codified under Subchapter F, Air Traffic and General Operating Rules, of Title 14 of the CODE OF FEDERAL REGULATIONS.

This FAA publication of the basic Part 101, effective September 30, 1963, incorporates Amendments 101-1 through 101-3, and any changes required by the Department of Transportation transition amendment.

**Part 101—Moored Balloons, Kites, Unmanned Rockets, and
Unmanned Free Balloons**

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Adoption of Part 101

Adopted: June 24, 1963

Effective: September 30, 1963

(Published in 28 F.R. 6702, June 29, 1963, effective September 30, 1963.)

This amendment adds to Subchapter F—Air Traffic and General Operating Rules [New] of Chapter I of Title 14 of the Code of Federal Regulations Parts 91 [New], 93 [New], 95 [New], 97 [New], 99 [New], 101 [New], and 103 [New]. It also adds several definitions to, and deletes one definition from, Part 1 [New]. The amendment is a part of the program of the Federal Aviation Agency to recodify its regulatory material into a new series of regulations called the "Federal Aviation Regulations" to replace the present "Civil Air Regulations" and "Regulations of the Administrator".

During the life of the recodification project, Chapter I of Title 14 may contain more than one Part bearing the same number. To differentiate between the two, the recodified Parts, such as the ones in this subchapter, will be labeled "[New]". The label will of course be dropped at the completion of the project as all of the regulations will be new.

This action was published as a notice of proposed rule making in the Federal Register on February 1, 1963 (28 F.R. 1003), and as Draft Release 63-3.

Some of the comments received recommended specific substantive changes to the regulations. Although some of the recommendations might, upon further study, appear to be meritorious, they cannot be adopted as a part of the recodification program. The purpose of the program is simply to streamline and clarify present regulatory language and to delete obsolete or redundant provisions. To attempt substantive changes in the recodification of these regulations (other than minor, relaxatory ones that are completely noncontroversial) would delay the project and would be contrary to the ground rules specified for it in the Federal Register on November 15, 1961 (26 F.R. 10698) and Draft Release 61-25. However, all comments of this nature will be preserved and considered in any later substantive revision of the affected Parts.

As a result of other comments received, several changes have been made in Subchapter F.

Sections 91.33 and 91.35 have been added to include the instrument and equipment requirements for general aviation aircraft that were contained in Part 43. Section 91.33 incorporates the instrument and equipment requirements for standard category aircraft from former § 43.30 and the DME provisions from former § 43.33. Section 91.35 incorporates the flight recorder requirements from former § 43.32. These changes have been made in recognition of the greater user convenience that results from combining these rules with the general operation provisions of Part 91 [New].

A new § 91.37 has been included in Part 91 [New] to cover weight limitations for transport category aircraft. This section is based upon former §§ 43.11, and 43T.11 of SR 422A and SR 422B. These provisions were omitted from DR 63-3 as surplus, but comments correctly pointed out the need for their inclusion in Part 91 [New].

Section 91.59 as proposed in DR 63-3 required compliance with the applicable marine rules of the road when operating an aircraft on water but it did not specifically spell out those rules. In order to avoid any misunderstanding as to the rules that must be complied with, that section has been revised to state those rules in detail and it now appears as § 91.69.

A number of changes have been made in proposed § 91.75. As proposed in DR 63-3, that section contained the air traffic rules for operating on or in the vicinity of airports, including specific provisions for controlled and uncontrolled airports. Because of the undue length of the section it has been broken down into three separate sections which now appear as §§ 91.85, 91.87, and 91.89. Paragraph (a) of proposed § 91.75 defined, for the purpose of that section, the terms "airport traffic area," "controlled airport," and "uncontrolled airport". The latter two terms were distinguished on the basis of whether or not the airport had a control tower. One comment received pointed out that under the present rules even an airport without a control tower becomes a "controlled airport" if it is located in a control zone and the weather in that zone goes below basic VFR minimums. Therefore, §§ 91.87 and 91.89 have been revised to eliminate those terms and to execute their definitions. In addition, because of its general applicability, the definition of "airport traffic area" has been transferred to Part 1 [New].

Two other changes have been made in proposed § 91.75. First, the word "arriving" has been inserted in the first sentence of paragraph (c) of § 91.85 so that it correctly reflects the scope of the rule on which it is based. Secondly, paragraph (d) of § 91.87 has been revised to apply only to aircraft "operating to" an airport. As this provision appeared in the draft release it would apply to aircraft operating "to, from, or on" an airport. While this language properly reflected the applicability of former § 60.18(b), one comment pointed out its incorrect applicability and this opportunity is being taken to correct it.

One comment noted that proposed § 91.73 relaxed the requirement of § 60.20 by permitting a pilot to notify the nearest "ATC facility" upon cancelling or completing flight under a flight plan rather than the nearest "control tower". This relaxatory change in the rule was intended, and it has been retained in § 91.83(a). In addition, the requirement for indicating aircraft color in a flight plan has been deleted from that paragraph, since it was not contained in § 60.41.

Certain changes, not contained in Draft Release 63-3, reflect amendments to the Parts revised herein that became effective after the draft release was published. Each of these amendments, when published, contained a statement that they would be included in the final draft of the recodified Parts affected and, in addition, Draft Release 63-3 stated that such amendments would be included in the final draft of the revised subchapter. Amendments 43-16, 43-17, 48-1, 60-31, 60-32, and 619-1 are therefore reflected in the new subchapter.

Other minor changes of a technical clarifying nature or relaxatory nature have been made. They are not substantive and do not impose any burden on regulated persons.

Of the comments received on Draft Release 63-3, several suggested changes in style, format, or technical wording. These comments have been carefully considered and, where consistent with the style, format, and terminology of the recodification project, were adopted.

Comments received regarding proposed § 91.77 indicated a misunderstanding of the provisions of that section. Under § 60.24, on which proposed § 91.77 was based, there were two types of flight test areas, "approved" areas and "designated" areas. Since the Administrator has never "designated" flight test areas, § 60.24(a)(2) has been dropped as obsolete. The remaining flight test area provisions are now included in § 91.93.

A number of comments received regarding proposed § 91.35 indicated that many persons were not aware that under Part 190 of the Civil Air Regulations a person operating a foreign civil aircraft in the United States under VFR rules had to file a VFR flight plan. As proposed, § 91.35 simply restated that provision and it has been retained without change in § 91.43.

It should be noted that CAMs and information notes that are still current but which have been deleted as part of this amendment, will be republished in the Agency's Advisory Circular System.

The recodification of the air traffic and general operating rules in Subchapter F does not change the applicability of those rules, nor does it affect those rules governing special operations that prevail over the general rules contained in that subchapter. In addition, a certificate of waiver or an exemption that involves a regulation recodified herein that is outstanding on the effective date of this amendment will continue to be effective according to its terms and conditions even though it refers to Part or section numbers no longer in existence. For example, an exemption from the VFR cruising altitude provisions of former § 60.32 would continue under the terms and conditions of that exemption, to allow deviation from those altitudes, even though § 60.32 has been superseded by § 91.109. At such time as a certificate of waiver or an exemption is renewed, section references will be revised to reflect the new section number. In view of this, it is not necessary for persons who hold certificates of waiver or exemptions to take any action due to the recodification and renumbering of the air traffic and general operating rules.

The definitions, abbreviations, and rules of construction contained in Part 1 [New] of the Federal Aviation Regulations apply to Subchapter F. When Part 1 [New] was adopted its preamble stated that it would be amended as necessary in order to apply to specific regulations as they were recodified. As part of this action Part 1 [New] is being amended to incorporate definitions found to be necessary because of the adoption of subsequently issued FARs, including Subchapter F. The definitions of "air traffic clearance," "air traffic control," and "airport traffic area" have been incorporated from Part 60. The definitions of "kite" and "rocket" have been incorporated from Part 48. The definitions of "air commerce," "foreign air commerce," "interstate air commerce," and "overseas air commerce" have been incorporated from § 101 of the Federal Aviation Act of 1958. In addition to these definitions, Part 1 [New] is being amended to include definitions of "category," "class," and "type" and to delete the definition of "pilot".

Interested persons have been afforded an opportunity to participate in the making of this regulation, and due consideration has been given to all relevant matter presented. The Agency appreciates the cooperative spirit in which the public's comments were submitted.

In consideration of the foregoing Chapters I and III of Title 14 of the Code of Federal Regulations are amended as follows, effective September 30, 1963.

This amendment is made under the authority of sections 307, 813(a), 402, 601, 602, 603, 902, 1110, and 1202 of the Federal Aviation Act of 1958 (49 U.S.C. 1348, 1354(a), 1372, 1421, 1442, 1443, 1472, 1510, and 1522).

Amendment 101-1

Miscellaneous Amendments

Adopted: December 26, 1963

Effective: April 3, 1964

(Published in 29 F.R. 45, January 3, 1964)

On November 1, 1962, notice was given in Draft Release 62-45 (27 F.R. 10656) that the Federal Aviation Agency had under consideration a proposal to amend Part 48 of the Civil Air Regulations to include regulations governing the operation of unmanned free balloons. The notice also proposed to amend the scope of Part 60 to exclude unmanned free balloons from the air traffic rules contained therein.

Regulatory action, as proposed, is required to provide the necessary compatibility between unmanned free balloon operations and other airspace activities. It is also necessary to provide for the protection of persons and property on the ground that are not associated with the operation of unmanned free balloons.

Eleven comments were received in response to the draft release. The National Aeronautics and Space Administration, the Air Line Pilots Association, the National Aviation Trades Association, the University of Minnesota, the Aircraft Owners and Pilots Association, and the National Center for Atmospheric Research endorsed the proposal as pre-

sented. The remainder of the comments generally supported the proposal but recommended certain changes. For continuity these recommendations will be considered in the sequence of the proposed rule.

The Department of the Army recommended that the term "size/weight ratio" be amplified to state more clearly how this ratio is computed. Therefore, that portion of the rule is modified; first, by reversing the term to read "weight/size" to more clearly show that it is the total weight of the payload package applied to the area of the smallest surface of such package; second, by adding a statement as to how the exact weight/size ratio can be determined.

One comment stated that the proposed regulation did not allow an operation to be conducted through a thin transparent cirrus cloud condition even though all other operating limitations were satisfied. Accordingly, it was recommended that there be provision for operations when such a cloud condition exists. The weather requirements adopted herein are necessary precautions to ensure that the balloon is operated in a manner that makes it easily seen and avoided by airplanes. Furthermore, since it is incumbent on the pilot of an airplane to see and avoid an unmanned free balloon by giving it right-of-way, a modification in the manner suggested would nullify a major safety objective to make balloon operations compatible with those of other airspace users. Therefore, no change is made in the operating limitations regarding cloud coverage and horizontal visibility.

One comment indicated a possible misconception regarding the lighting requirement during night operations. This requirement for lighting applies to the entire balloon assembly and not just to the balloon envelope. To eliminate any doubt, that portion of the rule is modified to clearly state that the requirement to light the balloon also applies to the entire balloon assembly, whether operated as one unit or separated during the operation.

The National Pilots Association recommended that all trailing antennas be marked with colored pennants or streamers since contact with the antenna by a small aircraft could produce an adverse effect if the antenna became entangled in the propeller. A light weight antenna that would be broken by a force of less than 50 pounds, which the proposal had exempted from such marking, is not suited for such attachments. A pennant or streamer attached to a light weight antenna has the tendency to float back up into the antenna and become entangled with it. This condition could nullify the purpose of the antenna, which is to supply altitude and D/F information to the balloon operator who, in turn, forwards the position and altitude to air traffic control. On this basis, no change is being made to that section of the rule.

Two other comments contended that marking an antenna so as to be visible for a minimum of one mile was inadequate. To increase this minimum, it would be necessary to require the use of a larger pennant or streamer. This could be a most difficult requirement for the balloon operator to meet and would generate the same previously mentioned nullifying effect on the use of the antenna. Therefore, no change is made to that section of the rule.

The Department of the Air Force and the Air Transport Association pointed out that the proposal did not require the suspension system to be marked in any way. In many cases it is not necessary to require by rule that the suspension system be marked because the plastic balloon bubble with its reflective surface is recognizable long before the suspension system would be seen. Additionally, a balloon suspension system of one or more open parachutes is already well marked and may be easily recognized since they normally employ high conspicuity colors such as aviation surface orange and white. We have, however, modified the rule to require that suspension systems, other than highly conspicuously colored open parachutes, exceeding 50 feet in length must be marked with colored pennants or streamers or alternate bands of high conspicuity colors. As discussed previously, in many cases it would be technically difficult to incorporate markings that would make a balloon subsystem easily recognizable much beyond one mile. Therefore, in addition to providing notice to airmen information about programmed balloon flights, the Agency will pursue an educational program by a continual reminder in the *Airman's Guide* and other aeronautical publications that flight below an unmanned free balloon should be avoided. In this reminder, all pilots will be advised that these balloons may have suspension devices and trailing antennas suspended beneath them that might be invisible until the aircraft is close to the balloon. This same type of notice has proven

successful in the past by reminding all pilots operating in coastal waters about airships that might have invisible cables suspended beneath them.

The U.S. Air Force and the Air Transport Association recommended that unmanned free balloons, while within positive control areas, be equipped with a functioning radar beacon transponder that would permit radar observation of the balloon by air traffic control. When Draft Release 62-45 was published, airborne radar beacon equipment was not considered readily adaptable to unmanned free balloons due to its weight and cost. In the meantime, a number of unmanned free balloons have been operated successfully utilizing beacon transponder equipment. These operations indicate that radar beacon equipment is adaptable for use on many unmanned free balloons. This equipment will undoubtedly be even more suitable when it is designed primarily for balloons with the view towards reduced weight, lower costs, and increased availability. In recognition of these matters, the Agency will issue a notice of proposed rule making to require a functioning radar beacon transponder on certain unmanned free balloons. Additionally, the use of such equipment may lend credence to a modification of certain of the weather requirements discussed earlier. During the development stages of the new notice, following the adoption of the rule contained herein, coordination with manufacturers of radar beacon equipment, balloon operators and other segments of the public will be conducted to obtain all possible opinions, recommendations, and reactions.

In view of the upward expansion of the positive control areas, all reference in the balloon position and notice requirements has been changed from 44,000 feet to 60,000 feet.

In consideration of the foregoing, Subchapter F of Chapter I of Title 14 of the Code of Federal Regulations is amended as follows.

This amendment is made under the authority of section 307 and 313(a) of the Federal Aviation Act of 1958 (49 U.S.C. 1348 and 1354).

This amendment becomes effective on April 3, 1964.

Amendment 101-2

Unmanned Free Balloon Equipment Requirements

Adopted: March 22, 1967

Effective: April 28, 1967

(Published in 32 F.R. 5254, March 29, 1967)

The purpose of this amendment is to alter the equipment requirements for the operation of unmanned free balloons.

The Agency published a Notice of Proposed Rule Making in the Federal Register on December 8, 1966, (31 F.R. 15490) circulated as Notice No. 66-43 which proposed dual and independent systems for releasing the payload and for terminating the flight of the balloon envelope, and a radar reflective capability on the balloon envelope. The response to this Notice indicated a general endorsement of the proposal.

In commenting on the proposal, the Air Line Pilots Association (ALPA) recommended that a clearance by air traffic control be required for free balloon flight and also suggested that the balloons be colored a high-visibility orange or yellow and be a minimum size of fifty feet in diameter unless carrying no more than a few ounces of weight.

A clearance for a balloon flight, as may be issued to other types of aircraft, is not practicable because unmanned free balloons cannot be controlled sufficiently to respond to clearances and instructions. In view of the other operating limitations specified in the Part, additional control is not considered to be necessary.

The nature of most scientific experiments that utilize high-altitude balloons would preclude the use of designated colors on the balloon envelope because problems involving heat absorption, light reflection, and other phenomena would be created, thereby interfering with the experiments being conducted.

With regard to the suggested minimum balloon size requirement, the size of the balloon is dependent, to a large extent upon the nature of the experiment being conducted,

and the altitude to which the payload must be carried. Limiting the size of unmanned balloons may unnecessarily restrict experiments utilizing balloons.

ALPA also recommended that the Agency specify minimum standards for the balloon payload cut-down, destruct, and radar reflective devices. To the extent practicable, this was done in the proposal. However, balloon operators and manufacturers have the necessary expertise for developing specific systems and devices so that the selection of the particular types of payload release systems, destruct methods, and radar reflective devices to meet the performance standards prescribed in this rule has been left to the determination of the manufacturers or operators.

Professor R. Brown recommended that the proposal be amended to require balloon payloads to be equipped with a radar reflecting device so that the payload could be tracked during its descent. Some benefit might be derived from that requirement and the matter may be considered for adoption in a subsequent proposal. However, as stated in Notice 66-43, there have been several instances recently where the flight of unmanned free balloons could not be terminated as planned, and these balloons became derelicts and drifted over large sections of the country presenting possible hazards to air navigation. Because of this, it is necessary that § 101.35(a) should be revised immediately to include the additional equipment requirements proposed in Notice No. 66-43.

The word "completely" relating to independent destruct and payload cut-down systems was included in subparagraphs (1) and (2) of the notice to emphasize the requirement that each system, device, or combination, in addition to having a separate operation, should have separate power sources, activators or similar components to function in the event of a total failure of the corresponding unit. It has, however, been omitted from the rule as being surplusage.

In consideration of the foregoing, § 101.35(a) of the Federal Aviation Regulations is amended, effective April 28, 1967.

This amendment is made under the authority of sections 307 and 313(a) of the Federal Aviation Act of 1958 (49 U.S.C. 1348 and 1354).

Amendment 101-3

Hazardous Operations

Adopted: May 19, 1970

Effective: May 26, 1970

(Published in 35 F.R. 8212, May 26, 1970)

The purpose of these amendments to Part 101 of the Federal Aviation Regulations is to prescribe additional regulations governing moored balloon and kite operations currently excepted from the application of Part 101 by virtue of size, capacity, or weight.

At the present time, Part 101 is applicable only to (1) moored balloons that exceed six feet in diameter or contain a gas capacity in excess of 115 cubic feet; (2) kites that weigh more than 5 pounds and which are intended to be flown at the end of a rope or cable; (3) all unmanned rockets except aerial fireworks displays and certain small rockets; and (4) certain unmanned free balloons.

Recently, the FAA has been made aware of certain developments and uses of moored balloons and kites, that are not within the scope of the present regulations, but which, nevertheless, impose an immediate danger to the operation of aircraft and a hazard to persons and property.

An airplane kite company is presently manufacturing kites that are capable of flights at altitudes ranging from 1,000 to 1,500 feet AGL. These kites do not come within the purview of Part 101 since each kite weighs less than 5 pounds.

Another manufacturer produces a multiple kite train weighing less than 2 pounds capable of reaching heights in excess of 1 mile and distances greater than 3 miles from where the operator is standing.

As recently as December, 1969, it was reported to the FAA that 70 jet aircraft were forced to detour from the path of a high flying kite at San Francisco International

Airport. Because of this, it became necessary to request a change in the airport traffic pattern so that the kite would not be ingested into a jet engine.

Of even greater moment is the effect certain moored balloons, currently excepted from the provisions of Part 101, are having upon the safety of aircraft in flight.

At Inglewood, California, a balloon operation was conducted for the purpose of interfering with air navigation to protest noise caused by "low-flying aircraft" utilizing the Los Angeles International Airport. After being prevented from using a balloon of 6 feet, or greater in diameter, the operator resorted to the use of a smaller balloon to avoid the applicability of Part 101. The FAA has been advised that legally it is extremely difficult to prevent balloon operations such as this, even though they present an immediate danger to aircraft in flight, unless appropriate amendments are made to Part 101.

Even though a moored balloon is less than 6 feet in diameter or has a gas capacity less than 115 cubic feet, the derogation to safety may be as great as if the moored balloon falls within the present regulation.

Although moored balloons may be operated free from regulatory constraint if less than 6 feet in diameter or 115 cubic feet gas capacity, the limited size of these objects makes it all the more difficult for a pilot to either detect the balloon and avoid striking it, or to see it in sufficient time to avoid the necessity of taking radical evasive action. In the latter case, injuries could result to passengers and crew, as well as placing excessive stresses upon the aircraft structure. Possible loss of control of the aircraft by the pilot is also a potential hazard. The latter possibility involves a major safety problem, since an incident of this type will occur during the approach or take-off phase of flight when the aircraft is being operated much closer to stalling speeds and relatively close to the ground.

By reason of the foregoing, a situation exists that demands immediate regulatory action involving moored balloons and kites. Because this regulatory action is needed immediately to correct an unsafe condition, it has been determined that in the public interest, notice and public procedure hereon are impracticable and for this reason good cause exists for making this amendment effective in less than 30 days.

In consideration of the foregoing, Part 101 of the Federal Aviation Regulations is amended, effective May 26, 1970.

(Sections 307(a) and 313(a) of the Federal Aviation Act of 1958; 40 U.S.C. 1348, 1354(a). Section 6(c) of the Department of Transportation Act; 49 U.S.C. 1655(c)).

Amendment 101-4

Objects Dropped from Certain Balloons, Kites, and Rockets

Adopted: June 13, 1974

Effective: August 20, 1974

(Published in 39 F.R. 22252, June 21, 1974)

The purpose of these amendments to Part 101 of the Federal Aviation Regulations is to add a provision governing the dropping of objects under that Part and to make other minor amendments.

Notice 73-15 was published in the Federal Register on May 7, 1973 (38 F.R. 11354), stating that the Federal Aviation Administration was considering an amendment to Part 101 of the Federal Aviation Regulations to include a provision governing the dropping of objects from moored balloons, kites, unmanned rockets, and unmanned free balloons, similar to the provisions in § 91.13 governing the dropping of objects from piloted aircraft.

In addition, it was proposed to amend Part 101 by changing the reference to "night" and "day" to read in terms of "sunset" and "sunrise." It was also proposed to amend § 101.85(b) to make it clear that the visibility requirements of that paragraph apply to lights and do not apply to a balloon and to its attachments.

Interested persons were afforded an opportunity to participate in the proposed rule making through the submission of comments.

One commentator suggested that the second sentence of the proposed amendment to § 101.7 be deleted since it was vague and unclear and tended to lessen the effect of the first sentence. The second sentence, as proposed, stated that "this section does not prohibit the dropping of any object if reasonable precautions are taken to avoid injury or damage to persons or property." The commentator stated that this language had the effect of diminishing the clear intent of the first sentence which stated that no person may allow 'an object to be dropped . . . if such action creates a hazard to persons or property.' The FAA agrees with this comment. This amendment omits the second sentence.

One commentator suggested that § 101.7 as written might preclude military air drops because of possible hazard to military property. The intent of this proposal was not to prevent a hazard to the property of the regulated person himself but rather to protect the property of other persons. Paragraph (b) of § 101.7, as added by this amendment, therefore, is reworded to specifically refer to hazards to "other persons, or to their property." This would further clarify the intent of the amendment to allow an operator to accept personal risk while limiting that risk so as to prevent possible risk to others. At the same time paragraph (a) of § 101.7 is amended to be consistent with this amendment. This revision includes deletion of the reference to "aircraft," since aircraft are covered by the word "property."

[Sections 307 and 313(a) of the Federal Aviation Act of 1958, 49 U.S.C. 1348, 1354(a); Section 6(c) of the Department of Transportation Act, 49 U.S.C. 1655(c)].

In consideration of the foregoing, Part 101 of the Federal Aviation Regulations is amended as follows, effective August 20, 1974.

Part 101—Moored Balloons, Kites, Unmanned Rockets, and Unmanned Free Balloons

Subpart A—General

§101.1 Applicability.

(a) This Part prescribes rules governing the operation, in the United States, of the following:

(1) Except as provided for in § 101.7 of this Part, any balloon that is moored to the surface of the earth or an object thereon and that has a diameter of more than 6 feet or a gas capacity of more than 115 cubic feet.

(2) Except as provided for in § 101.7 of this Part, any kite that weighs more than 5 pounds and is intended to be flown at the end of a rope or cable.

(3) Any unmanned rocket except—

- (i) Aerial firework displays; and
- (ii) Model rockets—

(a) Using not more than 4 ounces of propellant;

(b) Using a slow-burning propellant;

(c) Made of paper, wood, or breakable plastic, containing no substantial metal parts and weighing not more than 16 ounces, including the propellant; and

(d) Operated in a manner that does not create a hazard to persons, property, or other aircraft.

(4) Except as provided for in § 101.7 of this Part, any unmanned free balloon that—

(i) Carries a payload package that weighs more than four pounds and has a weight/size ratio of more than three ounces per square inch on any surface of the package, determined by dividing the total weight in ounces of the payload package by the area in square inches of its smallest surface;

(ii) Carries a payload package that weighs more than 6 pounds;

(iii) Carries a payload, of two or more packages, that weighs more than 12 pounds; or

(iv) Uses a rope or other device for suspension of the payload that requires an impact force of more than 50 pounds to separate the suspended payload from the balloon.

(b) For the purposes of this Part, a 'gyroglider' attached to a vehicle on the surface of the earth is considered to be a kite.

§101.3 Waivers.

No person may conduct operations that require a deviation from this Part except under a certificate of waiver issued by the Administrator.

§101.5 Operations in prohibited or restricted areas.

No person may operate a moored balloon, kite, unmanned rocket, or unmanned free balloon in a prohibited or restricted area unless he has permission from the using or controlling agency, as appropriate.

§ 101.7 Hazardous operations.

[(a) No person may operate any moored balloon, kite, unmanned rocket, or unmanned free balloon in a manner that creates a hazard to other persons, or their property.

[(b) No person operating any moored balloon, kite, unmanned rocket, or unmanned free balloon may allow an object to be dropped therefrom, if such action creates a hazard to other persons or their property.]

Subpart B—Moored Balloons and Kites

§101.11 Applicability.

This subpart applies to the operation of moored balloons and kites. However, a person

operating a moored balloon or kite within a restricted area must comply only with §101.19 and with additional limitations imposed by the using or controlling agency, as appropriate.

§101.13 Operating limitations.

(a) Except as provided in paragraph (b) of this section, no person may operate a moored balloon or kite—

- (1) Less than 500 feet from the base of any cloud;
- (2) More than 500 feet above the surface of the earth;
- (3) From an area where the ground visibility is less than three miles; or
- (4) Within five miles of the boundary of any airport.

(b) Paragraph (a) of this section does not apply to the operation of a balloon or kite below the top of any structure and within 250 feet of it, if that shielded operation does not obscure any lighting on the structure.

§101.15 Notice requirements.

No person may operate an unshielded moored balloon or kite more than 150 feet above the surface of the earth unless, at least 24 hours before beginning the operation, he gives the following information to the FAA ATC facility that is nearest to the place of intended operation:

- (a) The names and addresses of the owners and operators.
- (b) The size of the balloon or the size and weight of the kite.
- (c) The location of the operation.
- (d) The height above the surface of the earth at which the balloon or kite is to be operated.
- (e) The date, time, and duration of the operation.

§101.17 Lighting and marking requirements.

(a) No person may operate a moored balloon or kite [between sunset and sunrise] unless the balloon or kite, and its mooring lines, are lighted so as to give a visual warning equal to that required for obstructions to air navigation in the FAA publication "Obstruction Marking and Lighting".

(b) No person may operate a moored balloon or kite [between sunrise and sunset] unless its mooring lines have colored pennants or streamers attached at not more than 50-foot intervals beginning at 150 feet above the surface of the earth and visible for at least one mile.

§101.19 Rapid deflation device.

No person may operate a moored balloon unless it has a device that will automatically and rapidly deflate the balloon if it escapes from its moorings. If the device does not function properly, the operator shall immediately notify the nearest ATC facility of the location and time of the escape and the estimated flight path of the balloon.

Subpart C—Unmanned Rockets

§101.21 Applicability.

This subpart applies to the operation of unmanned rockets. However, a person operating an unmanned rocket within a restricted area must comply only with subparagraph 101.23 (g) and with additional limitations imposed by the using or controlling agency, as appropriate.

§101.23 Operating limitations.

No person may operate an unmanned rocket—

- (a) In a manner that creates a collision hazard with other aircraft;
- (b) In controlled airspace;
- (c) Within five miles of the boundary of any airport;
- (d) At any altitude where clouds or obscuring phenomena of more than five-tenths coverage prevails;
- (e) At any altitude where the horizontal visibility is less than five miles;
- (f) Into any cloud;
- (g) Within 1,500 feet of any person or property that is not associated with the operations; or
- (h) [Between sunset and sunrise.]

§101.25 Notice requirements.

No person may operate an unmanned rocket unless, within 24 to 48 hours before beginning the operation, he gives the following informa-

tion to the FAA ATC facility that is nearest to the place of intended operation:

- (a) The names and addresses of the operators.
- (b) The number of rockets to be operated.
- (c) The size and weight of each rocket.
- (d) The maximum altitude to which each rocket will be operated.
- (e) The location of the operation.
- (f) The date, time, and duration of the operation.
- (g) Any other pertinent information requested by the ATC facility.

Subpart D—Unmanned Free Balloons

§ 101.31 Applicability.

This subpart applies to the operation of unmanned free balloons. However, a person operating an unmanned free balloon within a restricted area must comply only with § 101.33 (d) and (e) and with any additional limitations that are imposed by the using or controlling agency appropriate.

Using limitations.

No person may operate an unmanned free balloon—

- (a) Unless otherwise authorized by ATC, in a control zone below 2,000 feet above the surface, or in an airport traffic area;
- (b) At any altitude where there are clouds or obscuring phenomena of more than five-tenths coverage;
- (c) At any altitude below 60,000 feet standard pressure altitude where the horizontal visibility is less than five miles;
- (d) During the first 1,000 feet of ascent, over a congested area of a city, town or settlement or an open-air assembly of persons not associated with the operation; or
- (e) In such a manner that impact of the balloon, or part thereof including its payload, with the surface creates a hazard to persons or property not associated with the operation.

§ 101.35 Equipment and marking requirements.

(a) No person may operate an unmanned free balloon unless—

- (1) It is equipped with at least two payload cut-down systems or devices that operate independently of each other;
- (2) At least two methods, systems, devices, or combinations thereof, that function independently of each other are employed for terminating the flight of the balloon envelope; and
- (3) The balloon envelope is equipped with a radar reflective device(s) or material that will present an echo to surface radar operating in the 200 MHz to 2700 MHz frequency range.

The operator shall activate the appropriate devices required by subparagraphs (1) and (2) of this paragraph when weather conditions are less than those prescribed for operation under this subpart, or if a malfunction or any other reason makes the further operation hazardous to other air traffic or to persons and property on the surface.

[(b) No person may operate an unmanned free balloon below 60,000 feet standard pressure altitude between sunset and sunrise (as corrected to the altitude of operation) unless the balloon and its attachments and payload, whether or not they become separated during the operation, are equipped with lights that are visible for at least 5 miles and have a flash frequency of at least 40, and not more than 100, cycles per minute.]

(c) No person may operate an unmanned free balloon that is equipped with a trailing antenna that requires an impact force of more than 50 pounds to break it at any point, unless the antenna has colored pennants or streamers that are attached at not more than 50-foot intervals and that are visible for at least one mile.

(d) No person may operate [between sunrise and sunset] an unmanned free balloon that is equipped with a suspension device (other than a highly conspicuously colored open parachute) more than 50 feet long, unless the

suspension device is colored in alternate bands of high conspicuity colors or has colored pennants or streamers attached which are visible for at least one mile.

§ 101.37 Notice requirements.

(a) *Prelaunch notice.* Except as provided in paragraph (b) of this section, no person may operate an unmanned free balloon unless, within 6 to 24 hours before beginning the operation, he gives the following information to the FAA ATC facility that is nearest to the place of intended operation:

- (1) The balloon identification.
- (2) The estimated date and time of launching, amended as necessary to remain within plus or minus 30 minutes.
- (3) The location of the launching site.
- (4) The cruising altitude.
- (5) The forecast trajectory and estimated time to cruising altitude or 60,000 feet standard pressure altitude, whichever is lower.
- (6) The length and diameter of the balloon, length of the suspension device, weight of the payload, and length of the trailing antenna.
- (7) The duration of flight.
- (8) The forecast time and location of impact with the surface of the earth.

(b) For solar or cosmic disturbance investigations involving a critical time element, the information in paragraph (a) of this section shall be given within 30 minutes to 24 hours before beginning the operation.

(c) *Cancellation notice.* If the operation is canceled, the person who intended to conduct the operation shall immediately notify the nearest FAA ATC facility.

(d) *Launch notice.* Each person operating an unmanned free balloon shall notify the nearest FAA or military ATC facility of the launch time immediately after the balloon is launched.

§ 101.39 Balloon position reports.

(a) Each person operating an unmanned free balloon shall—

- (1) Unless ATC requires otherwise, monitor the course of the balloon and record its position at least every two hours; and
- (2) Forward any balloon position reports requested by ATC.

(b) One hour before beginning descent, each person operating an unmanned free balloon shall forward to the nearest FAA ATC facility the following information regarding the balloon:

- (1) The current geographical position.
- (2) The altitude.
- (3) The forecast time of penetration of 60,000 feet standard pressure altitude (if applicable).
- (4) The forecast trajectory for the balance of the flight.
- (5) The forecast time and location of impact with the surface of the earth.

(c) If a balloon position report is not recorded for any two-hour period of flight, the person operating an unmanned free balloon shall immediately notify the nearest FAA ATC facility. The notice shall include the last recorded position and any revision of the forecast trajectory. The nearest FAA ATC facility shall be notified immediately when tracking of the balloon is re-established.

(d) Each person operating an unmanned free balloon shall notify the nearest FAA ATC facility when the operation is ended.

HIGH ALTITUDE BALLOONS (HIBAL)

A. PRE-LAUNCH NOTICE - File within 6 to 24 hours prior to launch with nearest FAA ATC (In Canada, with MOT).

1. Balloon Identification. _____.
2. Estimated date/time of launch. _____ / _____ Z. (Amend to remain within $\pm$ 30 minutes. Record delays below.)
3. Location of launch site. _____.
4. Float altitude _____ feet.
5. Forecast date/time/trajectory to 60,000 feet. _____ / _____ Z _____ mi. _____ deg. from _____ (Launch site)
(or when appropriate LAT _____ LONG _____).
6. Balloon height _____ ft; diameter _____ ft; suspended devices _____ ft; payload weight _____ lbs; antenna length _____ ft.
7. Flight duration _____ hr.
8. Forecast date/time/location of impact with surface of earth. _____ / _____ Z _____ (impact point)

PRE-LAUNCH NOTICE --

FILED AT _____ Z, FILED WITH _____ FILED BY _____ (Initials)

B. SOLAR FLARE or COSMIC DISTURBANCE. NOTICE will be filed 30 minutes to 24 hours prior to launch.

C. LAUNCH NOTICE - File IMMEDIATELY after launch.

1. Balloon identification. _____ . Launch date/time _____ / _____ Z. _____ (location)
(If requested) Revised date/time/trajectory to 60,000 ft. _____ / _____ Z _____ (impact point)
Revised date/time/location of impact. _____ / _____ Z _____ (impact point)
- LAUNCH NOTICE --
- | | | | |
|---|------------------------------------|----------------|------------|
| FILED AT _____ | Z, FILED WITH _____ | FILED BY _____ | (Initials) |
| 2. Delays FIRST DELAY UNTIL _____ / _____ | Filed at _____ Z, Filed with _____ | Filed by _____ | (Initials) |
| SECOND DELAY UNTIL _____ / _____ | Filed at _____ Z, Filed with _____ | Filed by _____ | (Initials) |
| THIRD DELAY UNTIL _____ / _____ | Filed at _____ Z, Filed with _____ | Filed by _____ | (Initials) |
| 3. Cancellation - File <u>IMMEDIATELY</u> . | Filed at _____ Z, Filed with _____ | Filed by _____ | (Initials) |

D. POSITION REPORTS - Record balloon position every two hours. Include DATE/TIME/LOCATION. (File only on request).

/	Z		/	Z		/	Z	
/	Z		/	Z		/	Z	
/	Z		/	Z		/	Z	
/	Z		/	Z		/	Z	
/	Z		/	Z		/	Z	
/	Z		/	Z		/	Z	
/	Z		/	Z		/	Z	

E. TERMINATION NOTICE - File ONE hour prior to shutdown (TWO hours in Canada).

1. Current date/time/position. / Z .
 2. Current altitude ft.
 3. Forecast date/time for penetration of 60,000 ft. / Z.
 4. Forecast trajectory, balance of flight. .
 5. Forecast date/time/location of impact. / Z .
- TERMINATION NOTICE -- FILED AT Z, FILED WITH , FILED BY (initials)

F. CLOSE-OUT NOTICE - Notify FAA ATC (MOT) when operation has ended.

END OF OPERATION NOTICE -- FILED AT Z, FILED WITH , FILED BY (initials)

G. TRACKING FAILURE NOTICE - If control and/or position are lost and cannot be reestablished within two hours:

1. File INITIAL NOTICE OF DERELICT as specified in paragraph 1 (a) of these instructions. (Appendix C 3)

H. ALL CLEAR NOTICE - If control and or position are reestablished, or the balloon and payload are confirmed down:

1. File an ALL CLEAR NOTICE with the facility in receipt of the INITIAL NOTICE OF DERELICT.

HIGH ALTITUDE BALLOONS (HIBAL)

I. DERELICT PROCEDURES FOR OPERATING AGENCIES (FROM OPNAV INST. 3710.18B)

If control of the launched object is lost/or its position becomes unknown, the operating agency will adhere to the following procedures:

(a) INITIAL NOTICE OF DERELICT. If control and/or position cannot be re-established by the operating agency within two hours from the time of loss, notify the nearest air traffic service facility. This notice shall include:

- (1) Brief description of the package; e.g., size of envelope, color, markings and lighting, length of trailing cable, size and weight of payload portion, etc.
- (2) Last known position and any forecast trajectory.
- (3) Name of competent and knowledgeable person(s) who will stand-by at a specified communications point to render any assistance that may be required.
- (4) A request that all above information be relayed to any other air traffic service or Air Defense facility that may be affected. This request will also include the above information be relayed to the Joint Chiefs of Staff (National Military Command Center (NMCC)), Washington, D.C., if the initial notice is given to any United States air traffic service facility (civil or military).

(b) ALL CLEAR NOTICE:

- (1) Whenever control and position are re-established by the operating agency, give an appropriate all-clear notice as soon as possible to the air traffic service facility which received the initial notice of derelict. This notice shall also include a request to relay the information to any other agency previously informed of control and position.
- (2) When this all-clear notice is given, or it is unquestionably determined that assistance is no longer required, the person(s) specified in (3) above is relieved of standby responsibility.

(c) REQUESTS FOR ASSISTANCE. Any request for assistance to re-establish position or provide surveillance shall first be directed to the air traffic service facility which received the initial notice of derelict. Such assistance may also be requested of any DOD military agency deemed appropriate, which in the CONUS and Alaska areas usually will be the NORAD (Air Defense) facility affected. However, to insure an over-all coordinated assistance effort, any such supplemental requests for assistance shall be made known to the air traffic service facility first contacted.

(d) REQUESTS FOR MILITARY DESTRUCTION OF DERELICTS:

(1) For Air Navigation Safety Reasons. Whenever unmanned friendly air-borne object becomes uncontrollable, the traffic services affected will determine that such object is or is not a menace to air navigation. Accordingly, any request by an operating agency (or other having knowledge) for destruction of an uncontrollable airborne object, believed to be a menace to air navigation, shall be first made as soon as possible to the nearest air traffic service facility. In turn, air traffic services may request appropriate military elements to take destroying action when the hazard cannot be countered by judicious control of air traffic. Subsequently, military elements will only use weapons to effect destruction when the imminence and magnitude of damage to air traffic, or other reasons, are overriding and warrant the calculated risk to personnel and property on the ground. In this regard, military elements will be governed by paragraph II.

(2) For Other Than Air Navigation Safety Reasons. Whenever an operating agency (or others having knowledge) believes an object warrants military destruction action, for reasons other than air navigation safety (security, possible acute political repercussions, etc.), the request shall be made to the Joint Chiefs of Staff by the fastest means of communications available.

(3) For Emergency Requests. Whenever the urgency of a situation requires immediate military destruction action to prevent an almost certain catastrophe, request for destruction by aircraft armament may be made to the nearest appropriate United States military agency.

(e) Responsibility for Initiation of Recovery of Derelicts. The initiation of recovery of derelicts, if required, is the responsibility of the operating agency.

II. DERELICT PROCEDURES FOR NONOPERATING DOD MILITARY AGENCIES:

(a) Requests For Tracking or Surveillance Assistance. Within their resources and capabilities, any military element shall provide every possible assistance in response to requests to track or maintain surveillance of a derelict airborne object.

(b) Requests for Destruction by Military Weapons:

(1) Normal Procedure. Military agencies in the CONUS and Alaska areas receiving requests to destroy derelicts or to provide surveillance assistance normally will send such requests to NORAD (Air Defense) for action and relay to appropriate authority. Requests received, from agencies other than the Joint Chiefs of Staff, to destroy a derelict airborne object shall be immediately forwarded to the Joint Chiefs of Staff for action and instructions by the fastest means of communications available.

(2) Emergency Procedure. On rare occasions, requests may be received by military commands to destroy derelict airborne objects by surface or airborne weapons and the situation requires immediate reaction, to prevent almost certain catastrophe. In such event and if circumstances prevent timely receipt of JCS approval, commanders of general rank or navy equivalent may direct destruction by conventional (nonnuclear) weapons only. Simultaneously with this emergency action, the Joint Chiefs of Staff will be notified as soon as possible of the action being taken and the circumstances of the emergency which required the action. For emergency requests, the following guidance to commanders is provided:

(a) Experience by military elements which have been involved in destruction of derelict balloons has shown that there is normally greater potential hazard to persons and property in the expenditure of weapons on these derelicts than is inherent in the derelict itself.

(b) Whenever a balloon envelope is ruptured or destroyed by weapons, the trajectory of fall of the payload package cannot be predicted accurately and surface contact can be many miles from the point over which the balloon envelope is ruptured.

- (3) Training and Test Procedure. An unmanned object may be destroyed by weapons without JCS approval if such destruction is planned as part of a recognized training or test program and is conducted within an appropriate airspace reservation and over a surface range, both of which are established for weapons firing.

QUESTIONNAIRE

1. Purpose
- 1.1 Describe briefly purpose of experiment.
2. Characteristics
- 2.1 Size and material of balloon.
- 2.2 Size and weight of payload.
- 2.3 Length of cable between balloon and payload.
- 2.4 Characteristics of cable (material, breaking strength, etc.).
- 2.5 Gas used, including information regarding any experiments with possible explosive effect from ingestion in aircraft engines.
- 2.6 Design operating altitude.
- 2.7 Design duration.
- 2.8 Marking or registration particulars.
3. Operation
- 3.1 Location of launchings.
- 3.2 Numbers (i.e. singly or in groups).
- 3.3 Any procedures for co-ordination of launching with aviation authority.
- 3.4 Any procedures for obtaining permission from States overflown.
- 3.5 Are trajectories estimated beforehand?
- 3.6 Are records kept of balloons unaccounted for?
4. Notification
- 4.1 Is a NOTICE issued for each launching and what detail is provided therein?
- 4.2 Do air traffic control centers warn air traffic about balloons at flight levels?
- 4.3 Is loss of balloon notified, and if so, how, by whom and to whom?
5. Tracking
- 5.1 Are balloons provided with radar reflector devices?
- 5.2 Are tracks of balloons monitored by radar, aircraft or otherwise, including location of descent?
6. Safety Devices
- 6.1 Methods used to remove balloons, straying inadvertently into flight levels or areas with significant air traffic (self-destructing devices, remote control destruction capability, shooting down, otherwise).
- 6.2 Reliability record of destruction devices.
7. Other Information
- 7.1 Any other information deemed pertinent to this inquiry.

Appendix D. COMMUNICATIONS

- D1. Coordination and Use of the 1435-
1535 MHz Telemetry Band
- D2. Radio Horizon Characteristics

**Coordination
And Use Of The
1435-1535 MHz
Telemetry Band**

BACKGROUND

In July 1960 the 1435-1535 MHz band, through the joint efforts of the Aerospace Flight Test Radio Coordinating Council (AFTRCC) and the military departments, was allocated for telemetry in addition to the 2200-2300 MHz telemetry band allocated in 1954. The 1435-1535 MHz band was allocated as a co-equal shared band between government and non-government users. The 2200-2290 MHz band is for government use only, and 2290-2300 MHz is a shared government and non-government band for deep space telemetry. Therefore, the only airborne telemetry band available to industry is the 1435-1535 MHz band and it is available only on a shared basis with government. The Office of Telecommunications Policy (OTP) Manual of Regulations and Procedures for Radio Frequency Management allocates the band as follows:

"In the band 1435-1485 MHz, 50 one-megahertz narrowband channels are designated, centered on 1435.5 MHz and each one-megahertz increment thereafter, through and including 1484.5 MHz. The use of emission bandwidths greater than 1 MHz is permitted, provided the assigned frequencies are centered on the center frequencies of narrowband channels. These channels are available for aeronautical telemetering a) primarily for the flight testing of manned aircraft or major components thereof, and b) secondarily for the flight testing of unmanned aircraft and missiles or major components thereof.

"In the band 1485-1535 MHz, 50 one-megahertz narrowband channels are designated, centered on 1485.5 MHz and each one-megahertz increment thereafter, through and including 1534.5 MHz. The use of emission bandwidths greater than 1 MHz is permitted, provided the assigned frequencies are centered on the center frequencies of narrowband channels. These channels are available for aeronautical telemetering a) primarily for the flight testing of unmanned aircraft and missiles or major components thereof and b) secondarily for the flight testing of manned aircraft or major components thereof.

"Included as permissible usage for aeronautical telemetering stations in the band 1435-1535 MHz is telemetry associated with launching and re-entry into the Earth's atmosphere, as well as any incidental orbiting prior to re-entry, of manned or unmanned objects undergoing flight tests.

"For the purpose of this plan, flight testing telemetry is defined as telemetry which is used in support of research, development, test, and evaluation, and which is not integral to the operational function of the system.

"In the band 1525-1535 MHz, the channels designated for aeronautical telemetering are also available for space telemetering on a shared basis. The band 1535-1540 MHz is available exclusively for space telemetering, but no specific channels have been established therein."

The Frequency Management Group of the Inter-Range Instrumentation Group (IRIG) and the AFTRCC have agreed that assignments in this band with emission bandwidths greater than 10 MHz will not be made nor coordinated except on a case-by-

case basis and only with complete and comprehensive justification. This policy will be reflected in the FCC Rules and Regulations. The usage of this band is also controlled by U. S. Footnote 78 to the National Tables of Frequency Allocation.

The Federal Communications Commission (FCC) and the Director of the Office of Telecommunications Policy (OTP) may both issue frequency authorizations in this band, and considerable alarm was expressed over the possibility of mutual interference. The primary users-government, and non-government in a given area could make the band unusable without field level coordination. The Aerospace Flight Test Radio Coordinating Council petitioned the FCC in 1968 for the establishment of an industry frequency advisory committee for the coordination of FCC assignments in the 1435-1535 MHz band (FCC Docket 18234). This docket was approved in January 1969 and AFTRCC was appointed as the Frequency Advisory Committee in May 1969.

The FCC, as a result of this docket, is requiring each application for a new license, renewal, or modification in the band to be accompanied by a statement from the Frequency Advisory Committee. The committee comments principally on the probability of interference of the proposal to existing stations. The committee may recommend frequencies, technical factors, and conditions or restrictions which would lessen the possibility of interference.

The OTP TELECOM Bulletin No. 4-69 of April 1, 1969 announced the initiation of a pilot program looking toward a formal government-wide program for improving field level selection and coordination of the use of radio frequencies. The initial step involved coordination of the use of frequencies in the band 1435-1535 MHz in the southern California area through the Department of Defense (DOD) Western Area Frequency Coordinator (WAFC) at Point Mugu, California. Effective June 1, 1970, the procedure was expanded to include the states of Nevada, Arizona, New Mexico, and Florida, and portions of the states of Utah, Colorado, Texas, Louisiana, Mississippi, Alabama, and Georgia through all of the other DOD Area Frequency Coordinators within the Conterminous United States (CONUS).

The OTP Notice to all Federal Users of Radio Frequencies dated 26 July 1971 expanded the program to include the remaining CONUS areas shown in Figure 1 and further discussed in Attachment A.

PROCEDURES

Non-Government Applicant

A non-government applicant making an application to the FCC for a frequency to be used for telemetry between 1435-1535 MHz is required to comply with the Frequency Coordination Regulations as stated in Section 87.334 of the FCC Rules and Regulations. For the purposes of this procedure, it is assumed that the requestor will elect to obtain his frequency coordination in accordance with Section 87.334 (c) (1). The request for frequency coordination will be made on the AFTRCC Form 87-1 and forwarded by the applicant to the AFTRCC, P.O. Box 718, Hawthorne, California 90250 as shown in Step Number 1 of Figure 2.

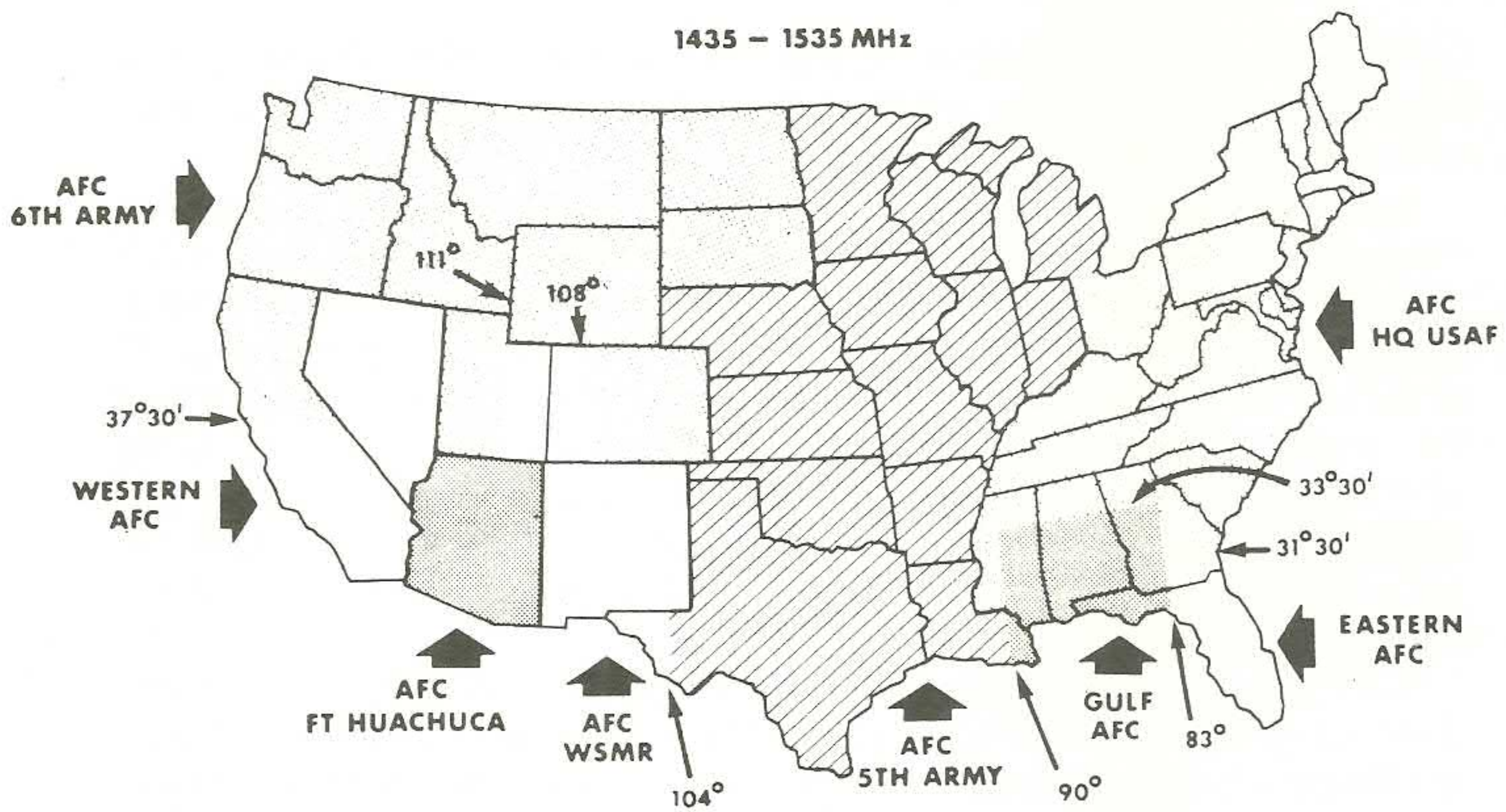
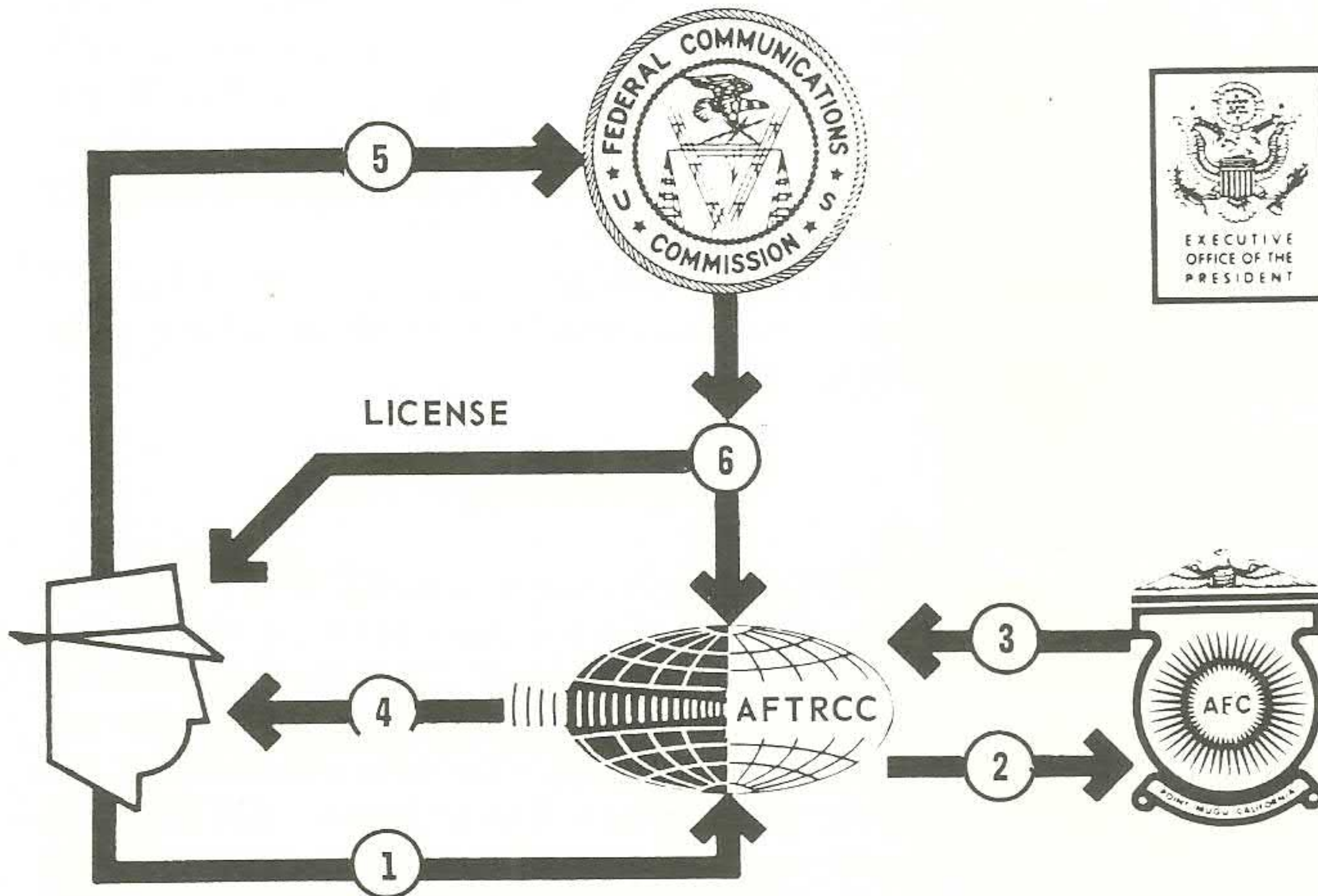


Figure 1. DoD Regional Coordination.

Figure 2. Non-Government Procedures.



Upon receipt of a completed form 87-1, the AFTRCC Frequency Advisory Committee will assign an identity control number and review information on the form for accuracy and completeness. If any items are questionable, the person making the request will be contacted for additional information.

If a specific frequency is requested, it will be compared with existing records on spectrum usage in the area of the proposed operation. If the records indicate the requested frequency is already utilized in a given area, or is likely to cause interference, an alternate frequency will be selected, for the protection of existing users as well as the applicant. If no frequency is specified, the Coordinating Committee will select a frequency based on the applicant's requirements, existing assignments, and technical particulars furnished by the applicant.

Upon selection of a frequency most likely to fulfill the applicant's requirements, copies of completed Form 87-1 shown in Step Number 2 of Figure 2 will be submitted to the cognizant Area Frequency Coordinator (AFC) for concurrence and/or comment. Comments may include any restrictive notes which, in the opinion of the AFC, should be added to the instrument of authorization.

When AFTRCC receives a request for frequency recommendation which involves the jurisdictional area of more than one AFC, the cognizant AFC will assign an AFC identity control number and obtain written clearance from all AFC's concerned.

The government AFC will sign the Form 87-3 and return it to the AFTRCC Coordinating Committee as shown in Step Number 3 of Figure 2. The committee will in turn prepare a Frequency Recommendation, Form 87-4 and forward it to the applicant as described in Step Number 4 of Figure 2. The applicant will attach Form 87-4 as a part of his application for license and forward it as indicated in Step Number 5 of Figure 2 to the FCC for processing.

The FCC, upon granting a radio license for the applicant, will forward a copy of the instrument of authorization to the AFTRCC as shown in Step Number 6 of Figure 2, to maintain an up-to-date record of frequency assignments. Copies of these licenses will also be forwarded by AFTRCC to the AFC involved for his records.

Government Applicant

A government applicant, including military, making an application through his agency's chain of command for a frequency to be used for telemetry between 1435-1535 MHz is required to comply with Annex D, Procedure for Field Level Selection and Coordination of the Use of Radio Frequencies, of the OTP Manual of Regulations and Procedures for Radio Frequency Management. The Government Frequency Application will be routed through the appropriate government AFC as described in Step Number 1 of Figure 3.

The government AFC's do not require a special form but will use government agency frequency application forms, i.e. USAF Form 38, USA 2212-R, AEC 310, NASA 556, OT 19 (OEP 88). The AFC will assign an identity control number (Attachment B) and review the form for accuracy and completeness. If the applicant wishes, the AFC will recommend a frequency based on the applicant's requirements

and the technical particulars furnished. The AFC will inform the applicant of the probability of any harmful interference involving the proposed assignment and if appropriate, will recommend either or both alternatives and restrictions to preclude such interference.

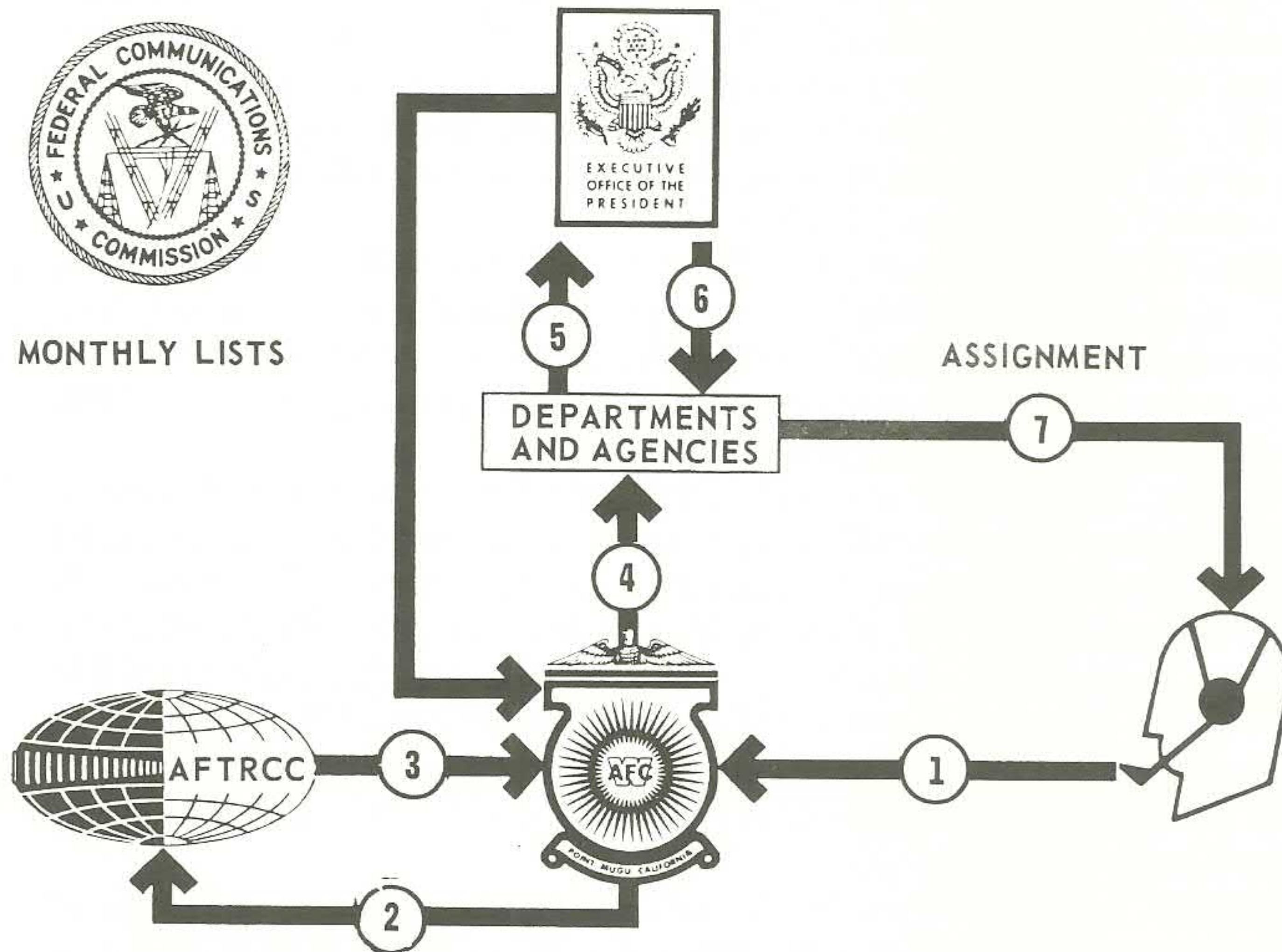


Figure 3. Government Procedures.

Upon agreement of the frequency and any required restrictions, the AFC will coordinate the proposed assignment with other AFC's and agencies as required. If there is no objection, all unclassified technical information, operating areas, etc., will be forwarded to AFTRCC for approval, as illustrated in Step Number 2 of Figure 3. The AFTRCC Frequency Advisory Committee will review and coordinate with non-government agencies as required and return the application with appropriate comments. Comments may include any restrictive notes (Step Number 3 of Figure 3) which, in the opinion of AFTRCC, should be added to the instrument of authorizations.

The Government Coordinator will incorporate the comments of the AFTRCC Frequency Advisory Committee with his own comments and forward the application on through the particular agency chain of command as described by Step Number 4 of Figure 3.

The Government Agency will ensure that the appropriate comments of the AFC and AFTRCC are reflected on the application submitted, as shown in Step Number 5 of Figure 3, to the Frequency Assignment Subcommittee (FAS) of the IRAC. The FAS will not approve such applications unless they bear the appropriate S-note indicating completion of the coordination required by this procedure. These S-notes read: "This frequency assignment was coordinated prior to authorization with the (name of AFC) who also coordinated it, as appropriate, with the Aerospace and Flight Test Radio Coordinating Council. Use of this frequency under the authority of this assignment is subject to such further coordination with the (name of AFC) as necessary to ensure compatibility with existing uses." Other coordination notes for the area concerned shall not be applied to such assignments. The appropriate S-notes are:

- S268 - Western AFC, Point Mugu, California
- S282 - AFC, Fort Huachuca, Arizona
- S283 - AFC, White Sands Missile Range, New Mexico
- S284 - Gulf AFC, Eglin AFB, Florida
- S285 - Eastern AFC, Patrick AFB, Florida
- S308 - Army AFC San Francisco, California
- S309 - Army AFC, Fort Sam Houston, Texas
- S310 - USAF Coordinator, Washington, D.C.

Upon FAS recommendation, an assignment to the Government Agency is authorized by the OTP as illustrated by Step Number 6 of Figure 3. The Government Agency will then, through agency channels, issue a radio frequency authorization to the applicant as shown by Step Number 7 of Figure 3.

BAND ASSIGNMENTS

For purposes of expediency, the 1435-1535 MHz band has been assigned to several research and development centers. The following locations have been assigned the entire band:

- AF Eastern Test Range, Florida
- AF Flight Test Center, California
- AF Armament Development Test Center, Florida
- Fort Huachuca, Arizona
- Fort Monmouth, New Jersey
- Holloman AFB, New Mexico
- Pacific Missile Range, California
- Redstone Arsenal, Alabama
- Vandenberg AFB, California
- White Sands Missile Range, New Mexico
- Naval Weapon Center, California

Each sub-assignment issued by the above Commands must be coordinated. Steps 1 through 3 in Figure 3 must be followed. However, the Government Coordinator will

not forward the application to Washington, but will return it with comments to the appropriate command listed above.

Government Coordinators, within whose area one of the above listed Commands falls, are responsible for ensuring each sub-assignment is coordinated with AFTRCC. Un-coordinated sub-assignments are not authorized (see "S" note under Procedures Section).

FREQUENCY SCHEDULING

Requirements for frequency scheduling or real-time coordination of usage to avoid harmful interference to other users will be indicated to the applicant during the preassignment coordination procedure. The office which will do the scheduling and the procedure to be followed will also be indicated.

FREQUENCY RECORDS

The Executive Secretary of the IRAC monthly informs each Government Coordinator of all FAS frequency assignment actions in the 1435-1535 MHz band. The FCC informs AFTRCC of all non-government frequency assignment actions.

These two records are combined by the WAFC and published every two months. The bi-monthly WAFC list also contains all local sub-assignments that have been coordinated with AFTRCC.

ATTACHMENT A

Coordinators - The Frequency Coordination specified in this procedure for the band 1435-1535 MHz shall be effected by liaison with the appropriate office listed below:

OFFICE	AREA
West. Area Freq. Coordinator Pt. Mugu, California 93042 Tel. (805) 982-8933 Autovon 873-8933	California south of 37° 30' N, including all offshore islands; Nevada.
HQ Sixth U. S. Army Army Area Freq. Coordinator Attn: AMOPT-CE-FC Presidio of San Francisco San Francisco, California 94129 Tel. (415) 561-3725 Autovon 586-5345/2807	California north of 37° 30' N; Colorado east of 108° W; Idaho; Montana; North Dakota; Oregon; South Dakota, Utah west of 111° W; Washington, Wyoming.
Area Frequency Coordinator Ft. Huachuca, Arizona 85613 Tel. (602) 538-3319 Autovon 879-3319	Arizona
Area Frequency Coordinator WSMR, New Mexico 88002 Tel. (915) 678-5417 Autovon 258-3702	Colorado west of 108° W; New Mexico; Texas west of 104° W; Utah east of 111° W.
HQ Fifth U. S. Army Army Area Freq. Coordinator Attn: ALACE-P Ft. Sam Houston, Texas 78234 Tel. (512) 221-4845 Autovon 471-4845/5326	Arkansas; Illinois; Indiana; Iowa; Kansas; Louisiana west of 90° W; Michigan; Minnesota; Missouri; Nebraska; Oklahoma; Texas east of 104° W; Wisconsin.
Gulf Area Freq. Coordinator Eglin AFB, Florida 32542 Tel. (904) 882-4416 Autovon 872-4416	Alabama south of 33° 30' N; Florida west of 83° W; Georgia west of 83° W, south of 33° 30' N; Louisiana east of 90° W; Mississippi east of 90° W, south of 33° 30' N.

Eastern Area Freq. Coordinator
Patrick AFB, Florida 32925
Tel. (305) 974-4208
Autovon 854-4208

Florida east of 83° W; Georgia east of 83° W,
south of 31° 30' N.

HQ USAF (PRCF)
Freq. Coordinator, Bldg. T-8
Washington, D. C. 20330
Tel. (202) 896-9269
Autovon 286-9269

Alabama north of 33° 30' N; Connecticut; Delaware; District of Columbia; Georgia north of 31° 30' N, east of 83° W; and north of 33° 30' N, west of 83° W; Kentucky; Maine; Maryland; Massachusetts; Mississippi less east of 90° W, south of 33° 30' N; New Hampshire; New York; New Jersey; North Carolina; Ohio; Pennsylvania; Rhode Island; South Carolina; Tennessee; Vermont; Virginia; West Virginia.

Aerospace and Flight Test
Radio Coordinating Council
AFTRCC
P.O. Box 718
Hawthorne, California 90250
Tel. (213) 392-9513

Continental United States

ATTACHMENT B IDENTITY NUMBERS

The listed blocks of Frequency Coordination Control Identity Numbers have been assigned to the indicated coordinators. The identifier when assigned will be followed by a dash and the last two digits of the calendar year, i.e., 000-00.

COORDINATOR	IDENTIFIER
AFTRCC	001-099
WAFC	100-199
GAFC	200-299
AFC Fort Huachuca	300-399
AFC WSMR	400-499
EAFC	500-599
AFC Sixth Army	600-699
AFC Fifth Army	700-799
USAF Frequency Coordinator	800-899

D2. RADIO HORIZON CHARACTERISTICS

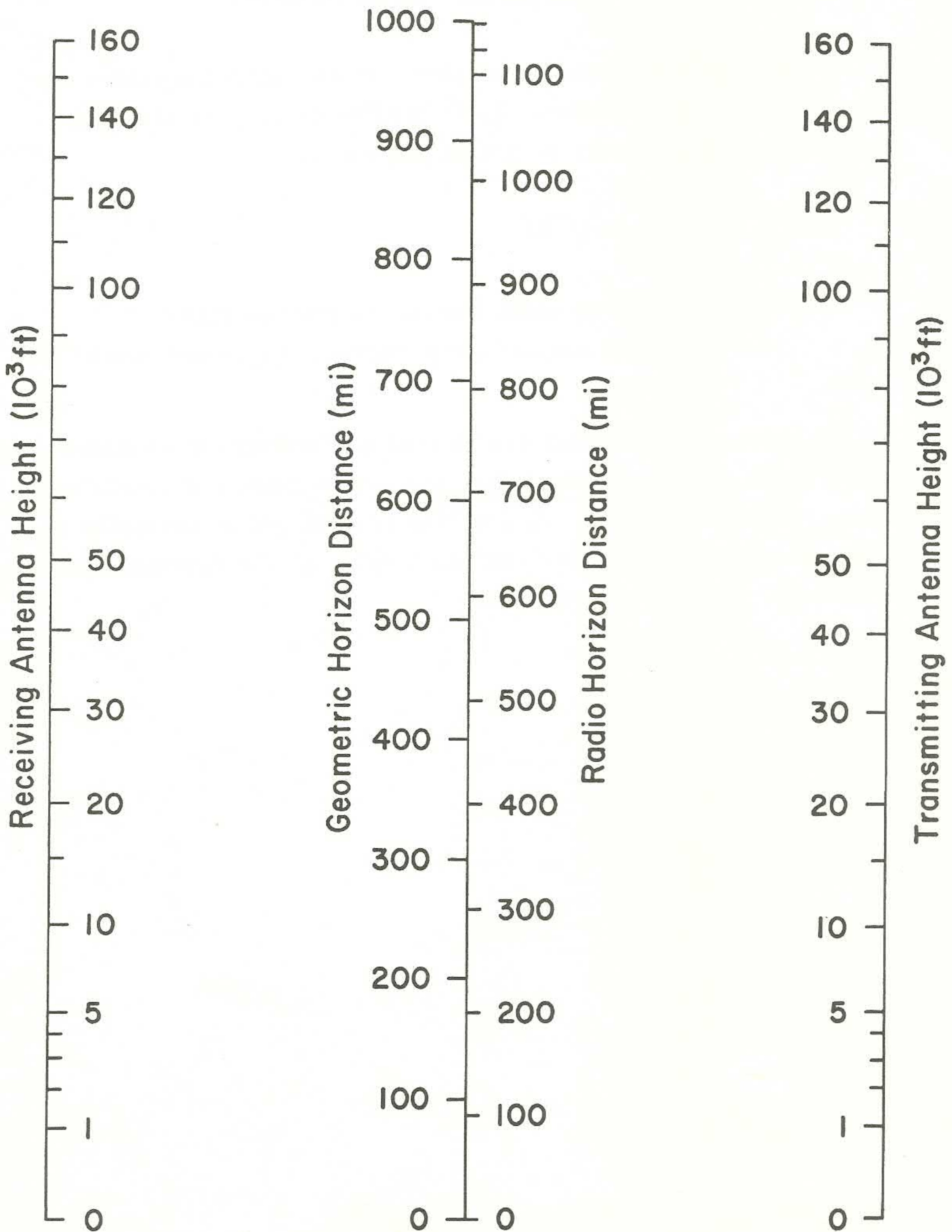
For average atmospheric conditions, the simplified equation for radio horizon is given below. It is applicable only to flat and shadowless topography such as plains and ocean.

$$D = \sqrt{2H}$$

where D = Distance to radio horizon in statute miles

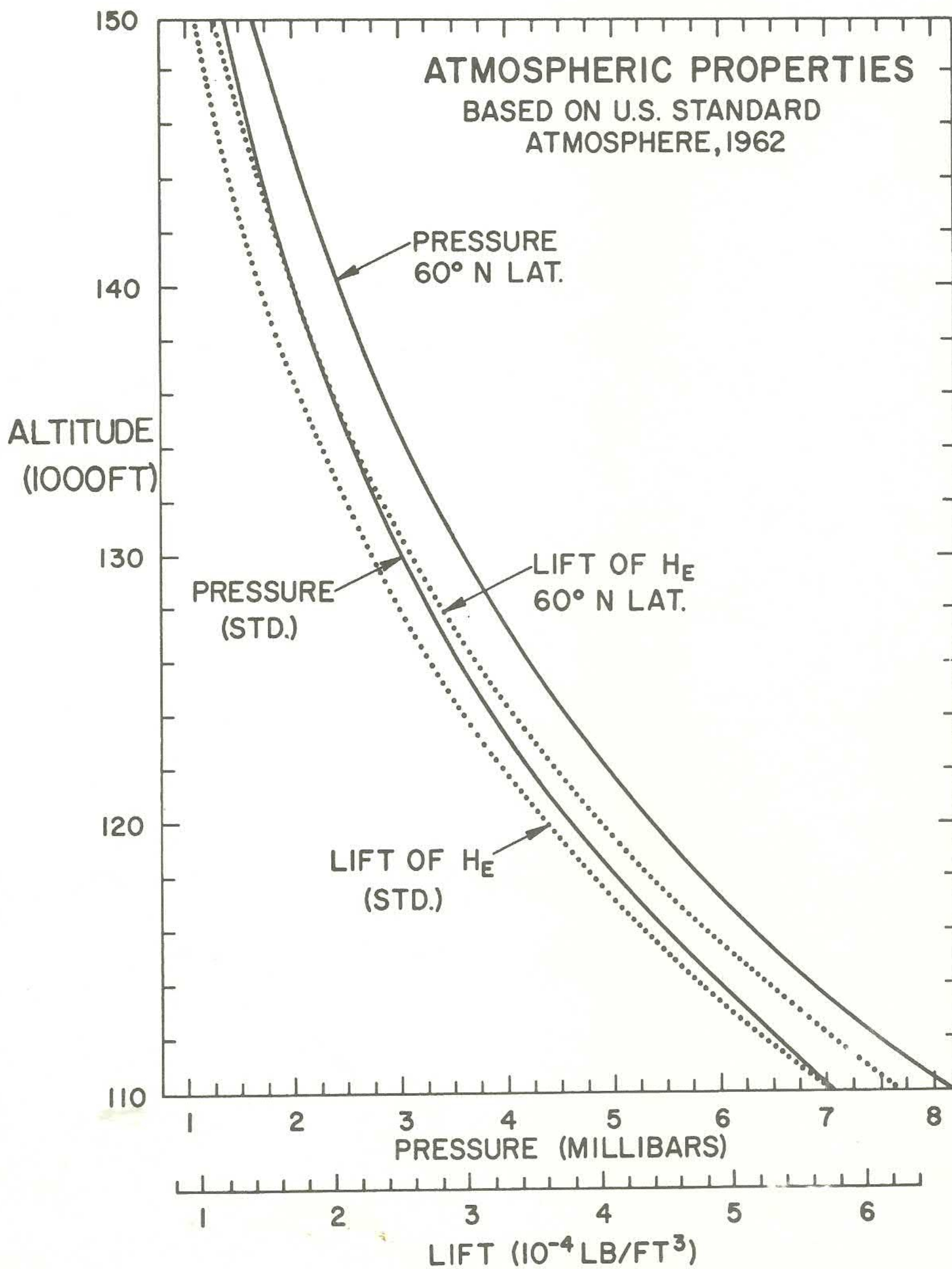
H = Height of antenna above surrounding ground level
in feet.

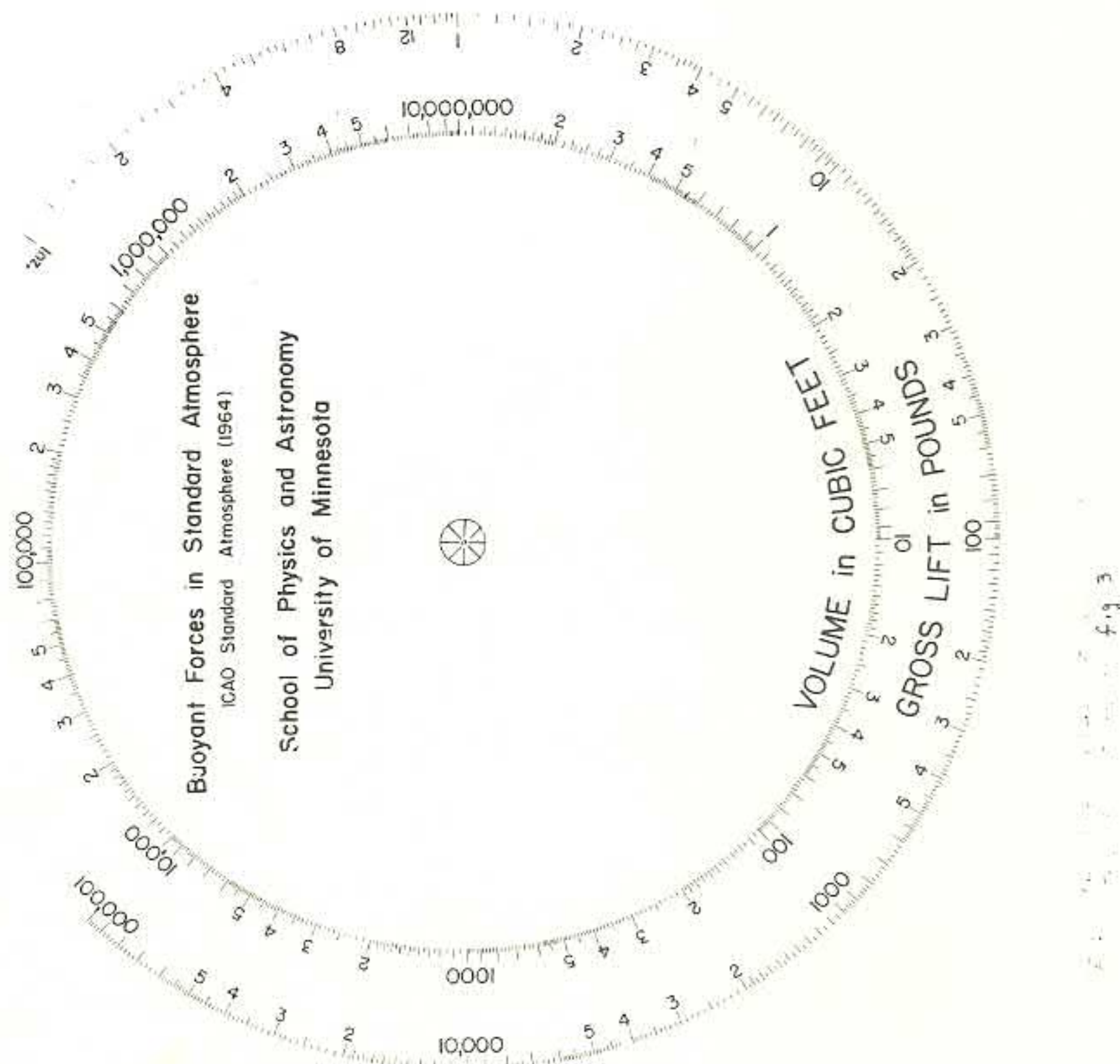
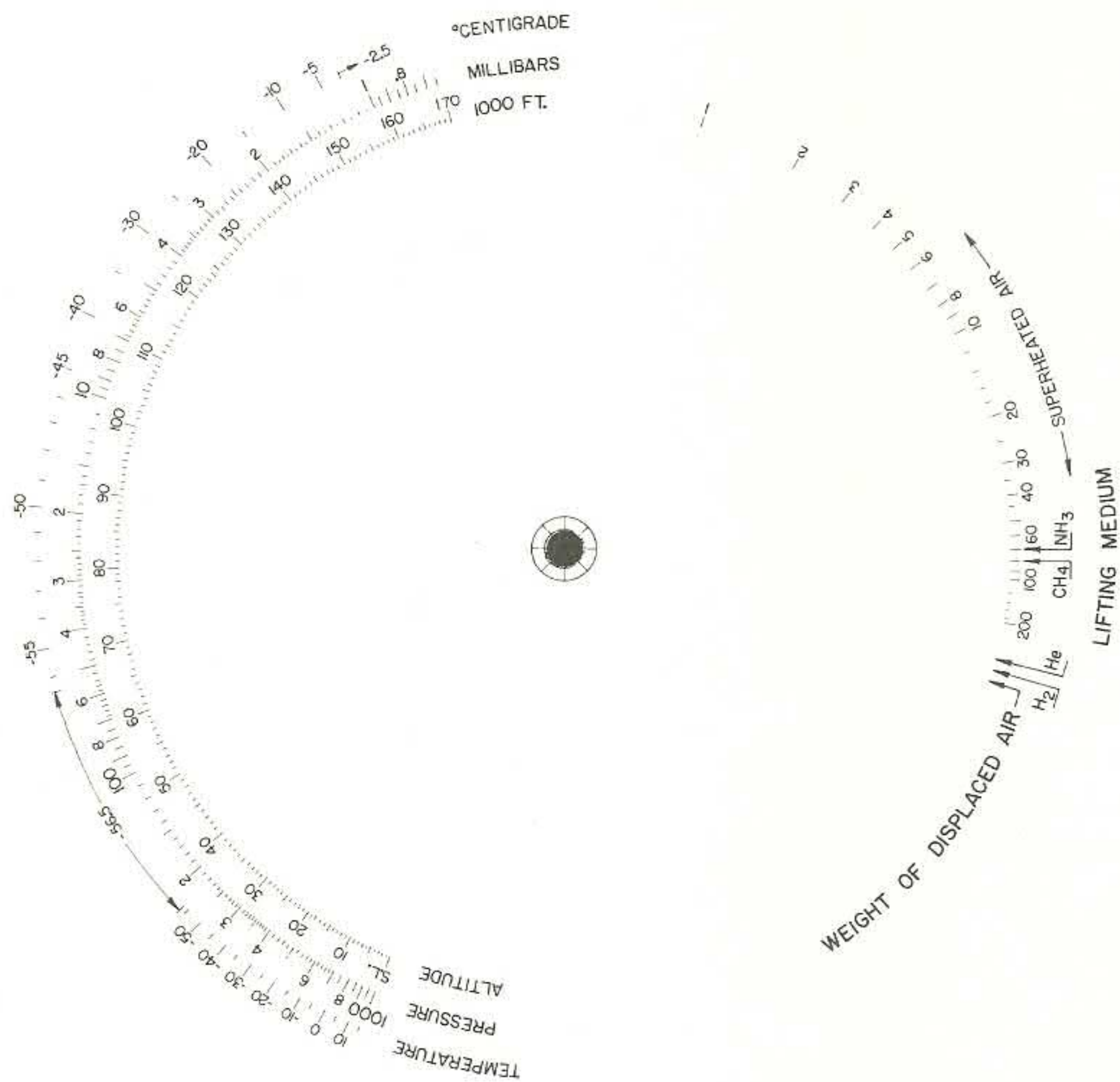
The nomograph following can be used to determine the maximum radio line of sight that is obtained when the transmitting and receiving antenna heights are known. It can also be employed to determine an antenna height when the other antenna height and the distance traversed are known.

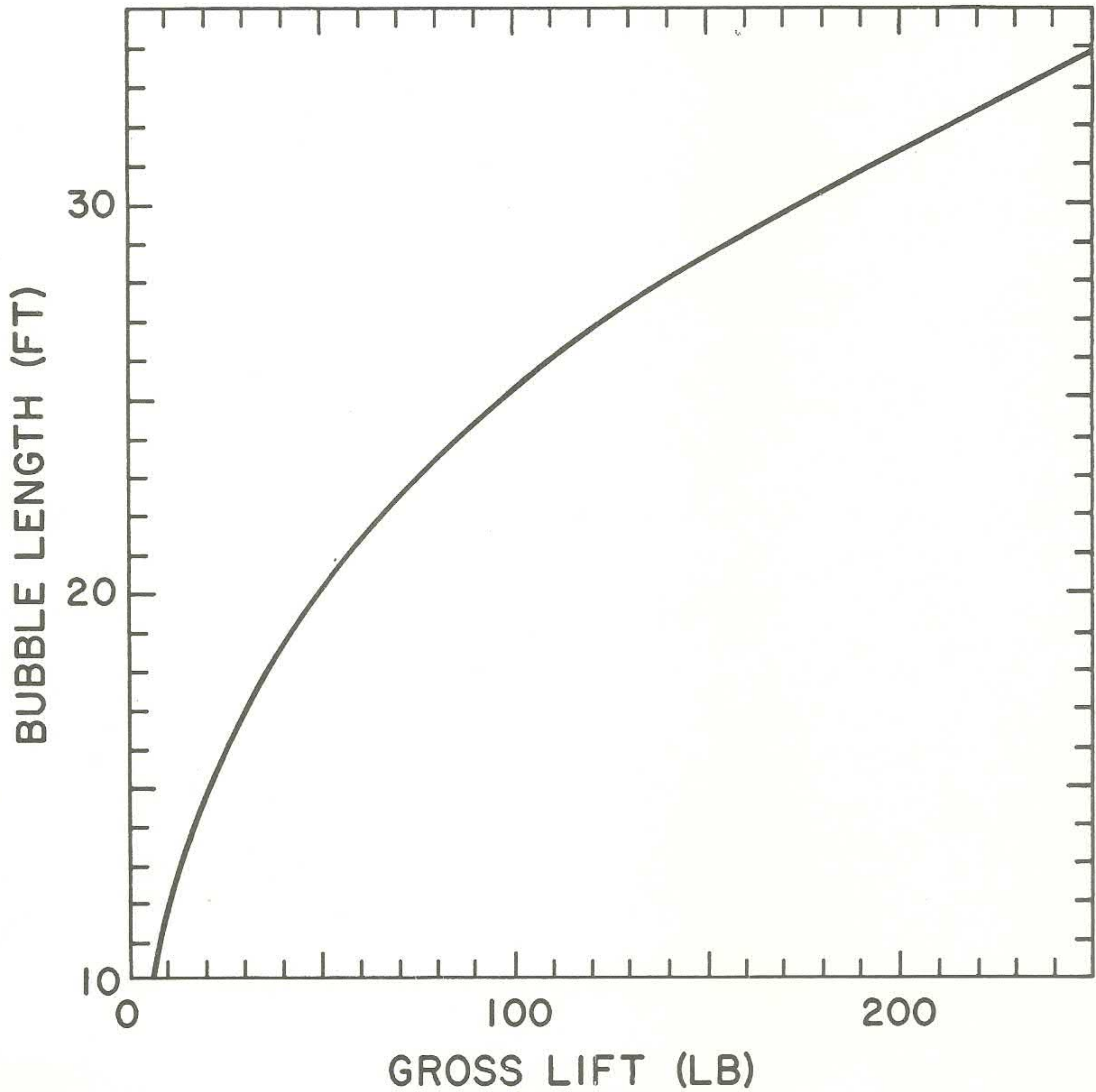


Appendix E. OPERATIONS

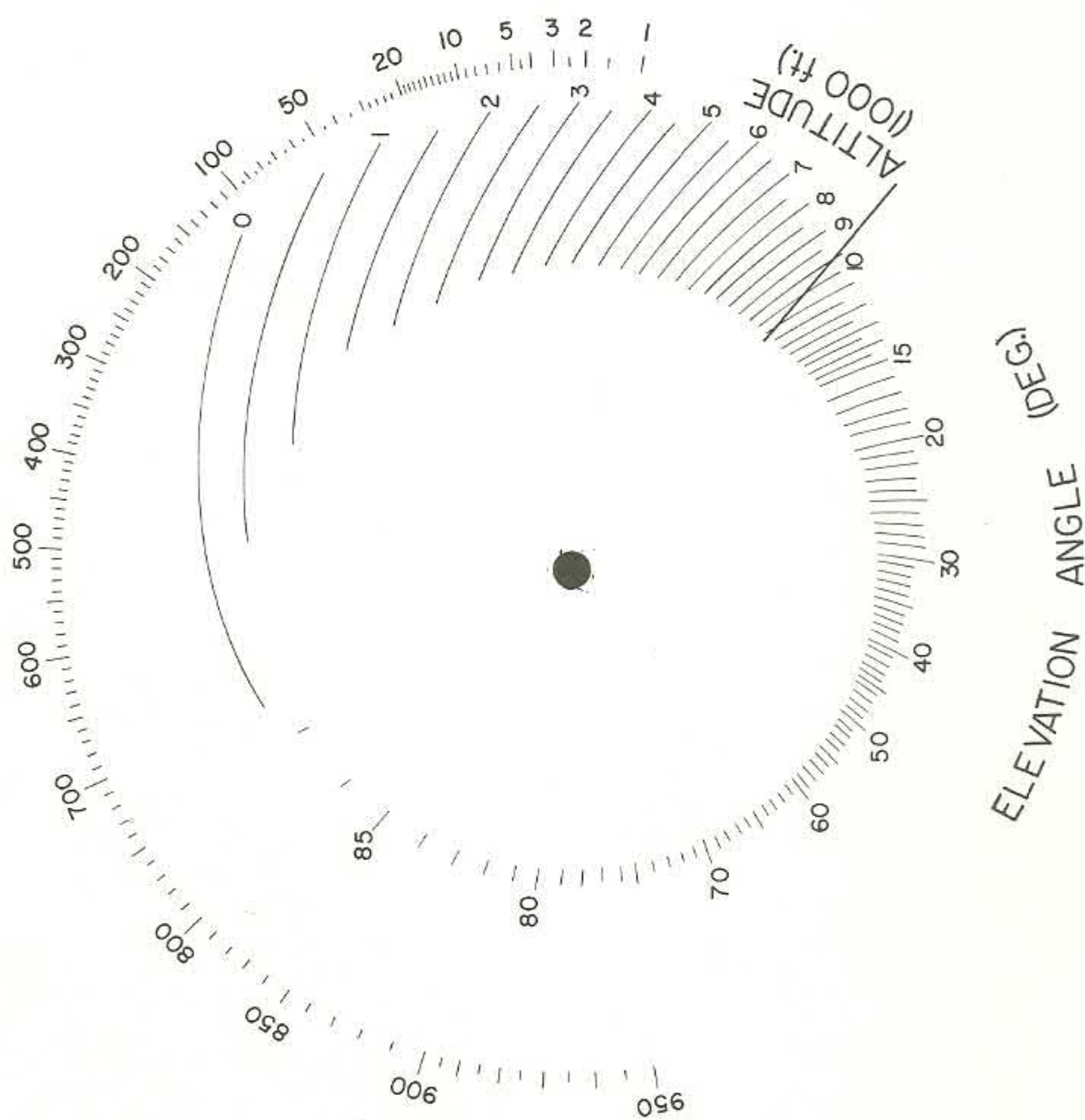
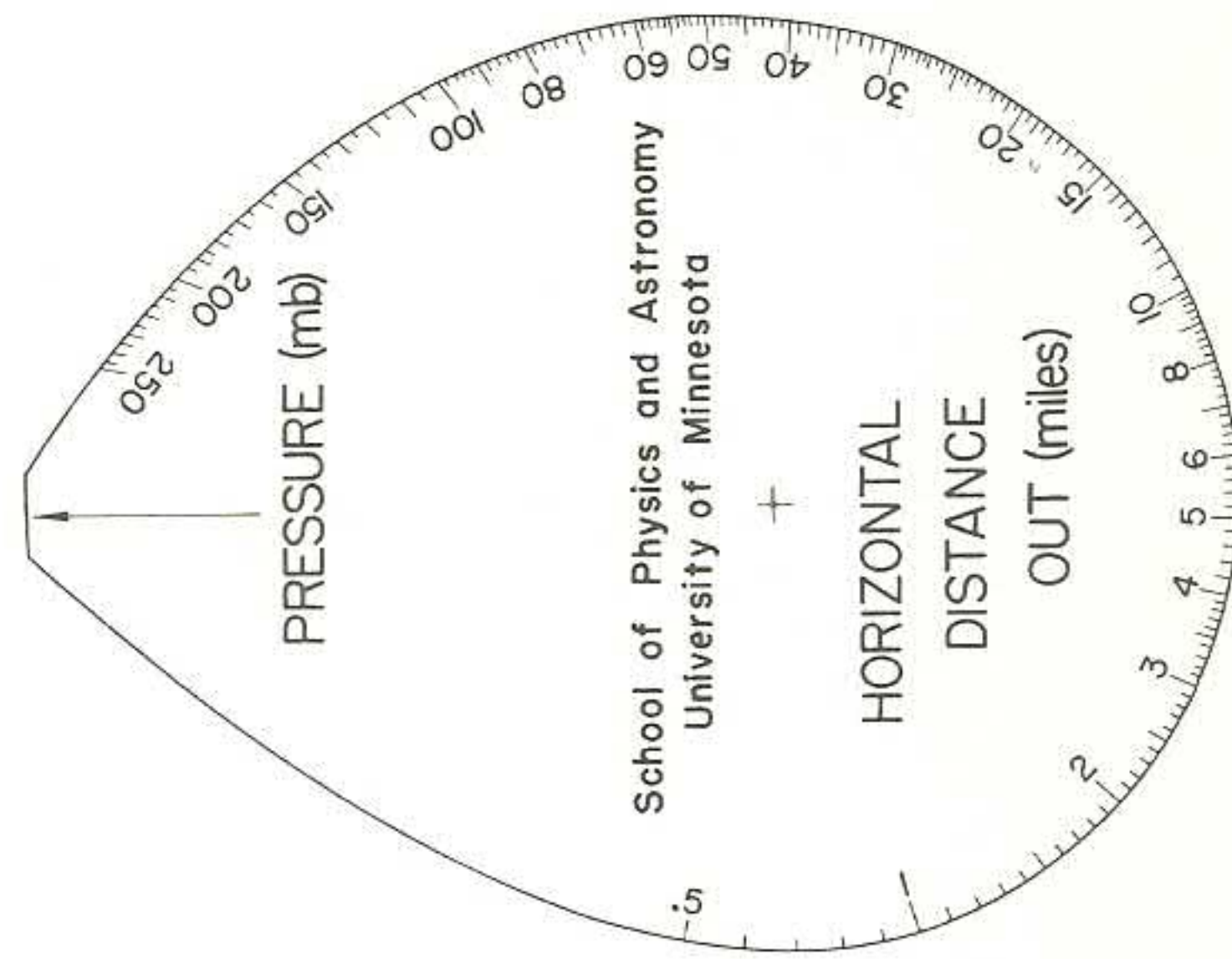
- E1. Atmospheric Properties; Buoyancy of Helium Gas
- E2. Balloon Performance Calculator
- E3. Balloon Launch Bubble Length
- E4. Horizontal Distance Calculator
- E5. Parachute Performance Calculator
- E6. Lines and Knots
- E7. Aircraft Flight Tracking Procedures
- E8. Inflation Tables
- E9. Gas Safety Precautions

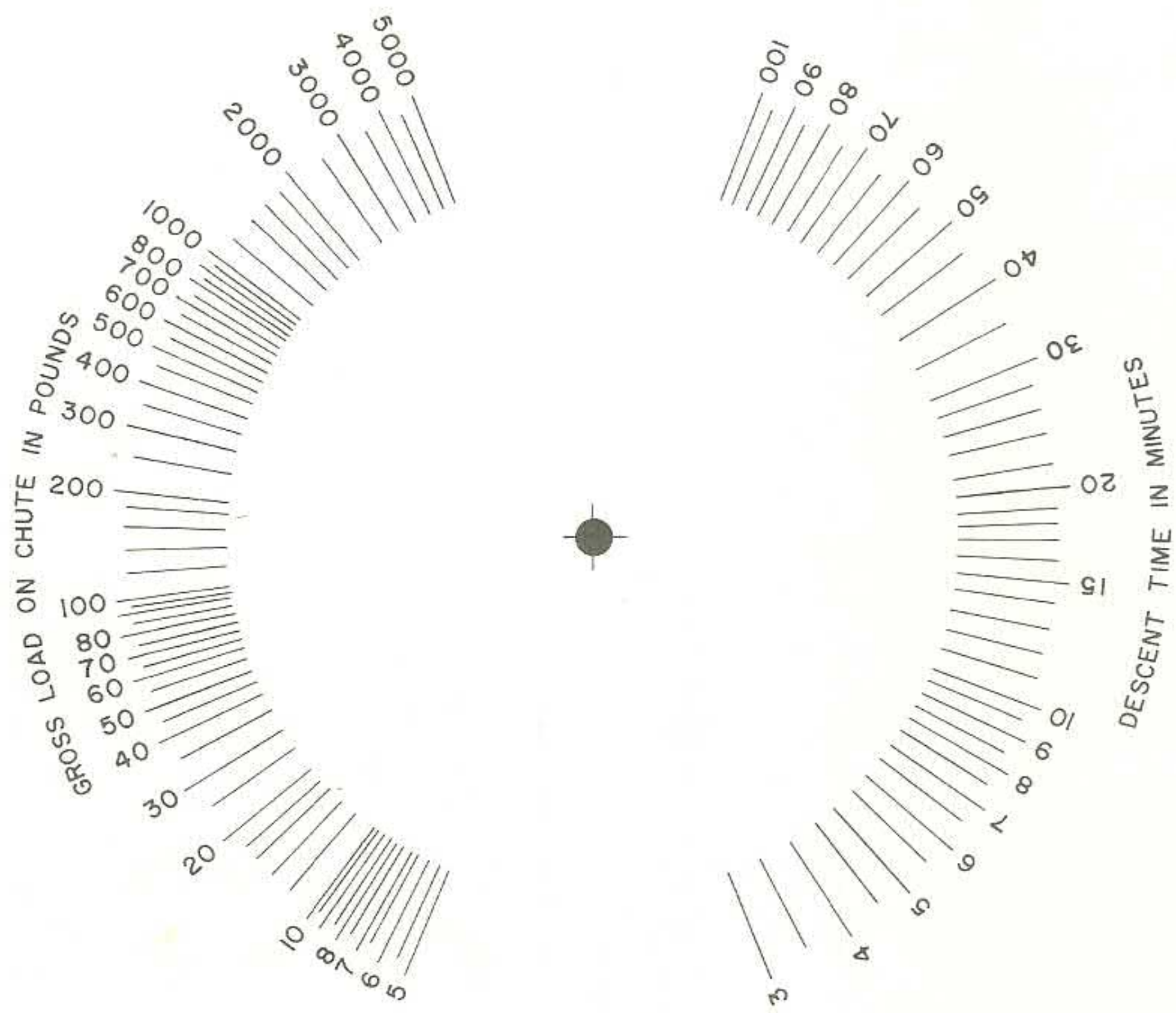
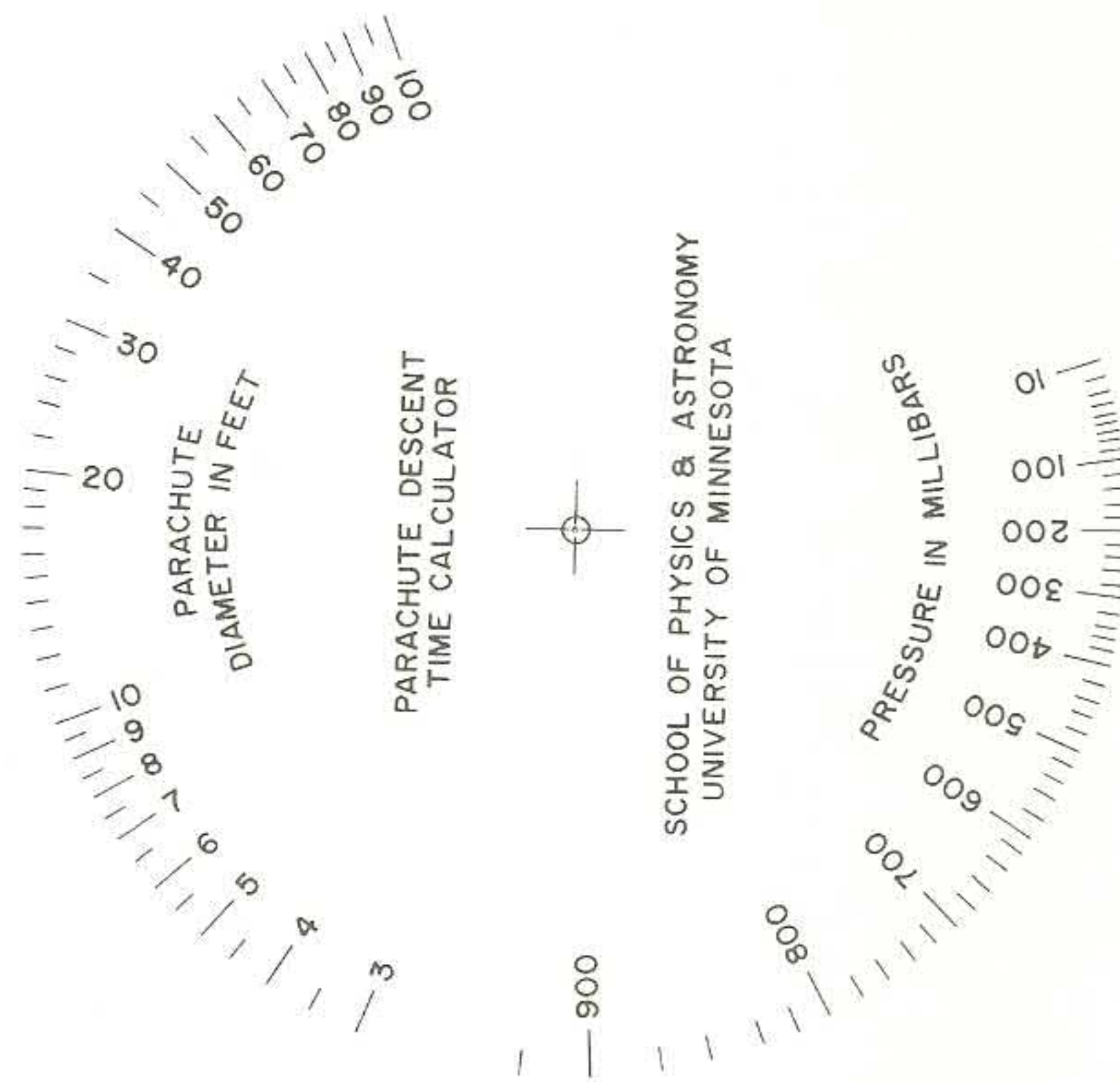




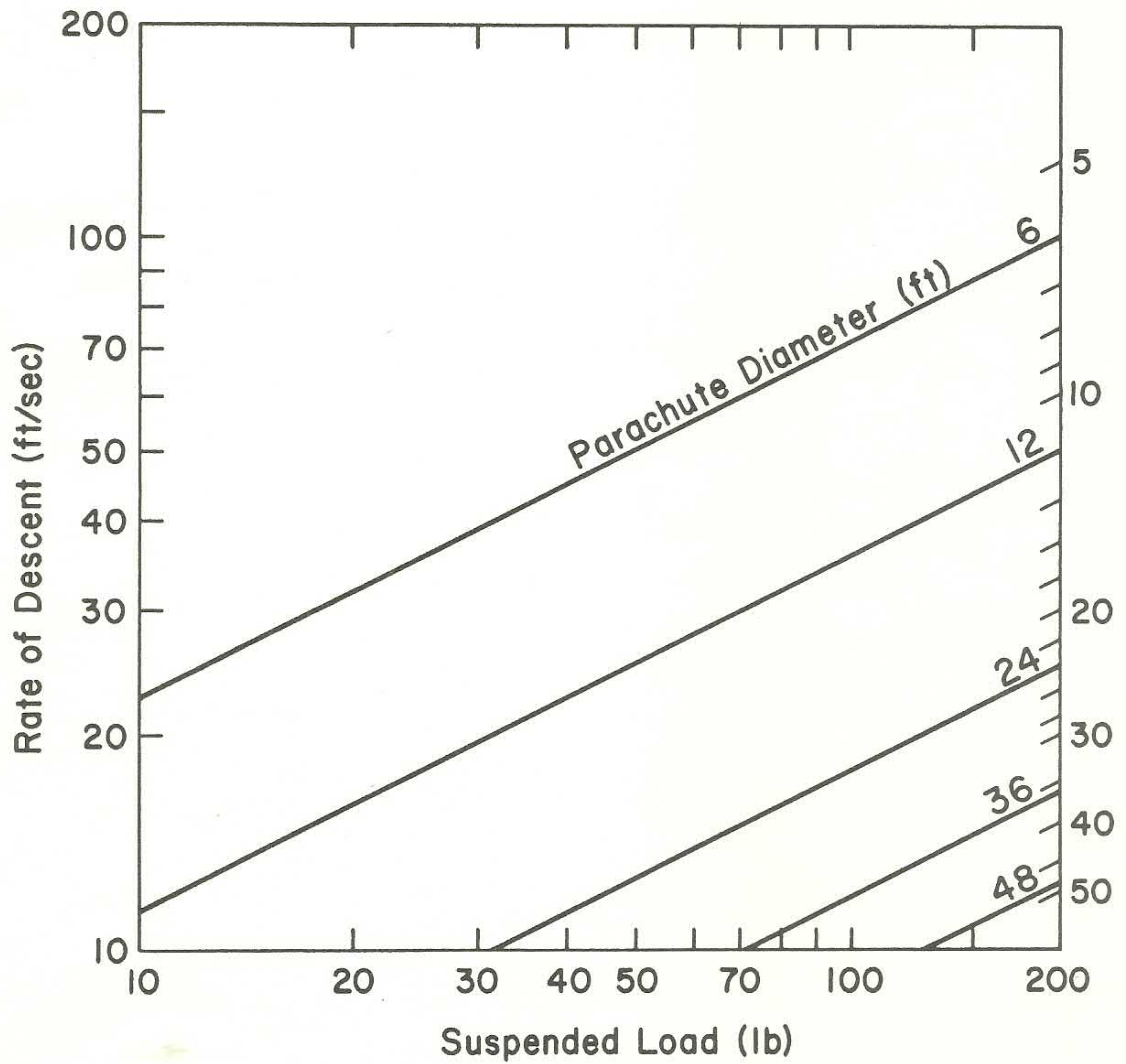


Length of bubble, prior to inflation, for locating the 'Huch Clutch.'
(Based on helium gas and sea-level inflation.)





Parachute Performance Calculator



Parachute Rate of Descent for
Various Sizes and Loads

E6. LINE AND KNOTS

Of the many fiber lines available, NYLON line, with its very high strength to weight ratio, is perhaps most commonly used in the makeup of the suspension system. Nominal sizes and breaking strengths of some NYLON lines are shown in the table below.* A minimum safety factor of 4, (maximum working load of one-fourth nominal breaking strength), should always be observed. Many operators insist on a safety factor of 10, (working load equal to one-tenth of the nominal breaking strength).

Nominal Breaking Strength of NYLON Lines

<u>Size (in)</u>		<u>Nominal Strength (lb)</u>	<u>Working Load (lb)</u>	
<u>Dia.</u>	<u>Cir.</u>		<u>Max. Safe</u>	<u>Max. Suggested</u>
3/16	5/8	1000	250	100
1/4	3/4	1500	375	150
5/16	1	2500	625	250
3/8	1-1/8	3500	875	350
7/16	1-1/4	4800	1200	480
1/2	1-1/2	6200	1550	620

*Printed, by permission, from MARKS STANDARD HANDBOOK FOR MECHANICAL ENGINEERS, Seventh Edition. McGraw-Hill, New York, 1967.

E7. AIRCRAFT FLIGHT TRACKING PROCEDURES

I. Before Launch

A. Pre-launch notice must be filed with the FAA in accordance with FAA Regulations, Part 101.

B. Tracking aircraft should be pre-flighted, run-up and balloon control equipment checked for satisfactory performance.

II. After Launch and until reaching Float Altitude

A. The tracking pilot should be immediately available to become airborne in the event of balloon failure. The most critical period is when the balloon goes through the cold layer. If the balloon is over 25 minutes flight time away from the launch site when going through this layer, then the pilot should become airborne to afford maximum security for the scientific package.

III. After reaching Float Altitude

A. It is desirable to obtain a position on the balloon as soon as possible after reaching float and again one-half hour later to obtain a ground speed and track on the balloon. Positions should be obtained a minimum of once each two hours.

B. During the day in VFR conditions, it is relatively simple to get a position on the balloon. Fly directly under the balloon and then record your position and time. This can be done with one omni receiver and DME or using two omni receivers on two stations and using a cross fix to locate your position. A sectional map is recommended for plotting purposes, due to the greater detail on it.

C. To obtain a position on the balloon at night or with a high overcast condition is a little more difficult. Using low frequency, home on the balloon with an Automatic Direction Finder (ADF) equipped with a beat frequency oscillator. When approaching the vicinity of the balloon, the ADF needle will start to wander a little, the volume will grow louder. Keep heading corrections small. When nearly under the balloon, the audio signal will fade due to a cone of silence under

the balloon transmitting antenna. The signal will fade out for two to three minutes, so approximately one minute after the fade out started, record your position and time. Also within two or three minutes, you will get a definite swing on the ADF indicating that the balloon is behind you. To obtain the most accurate ground speed and track, fly under the balloon from the same direction each time. The altitude of the balloon should be recorded also.

IV. Before Termination

A. At least one hour before termination, a notice must be filed with the FAA in accordance with Part 101.

B. Continue to obtain positions on the balloon. A position no later than 10 minutes before termination is highly desirable.

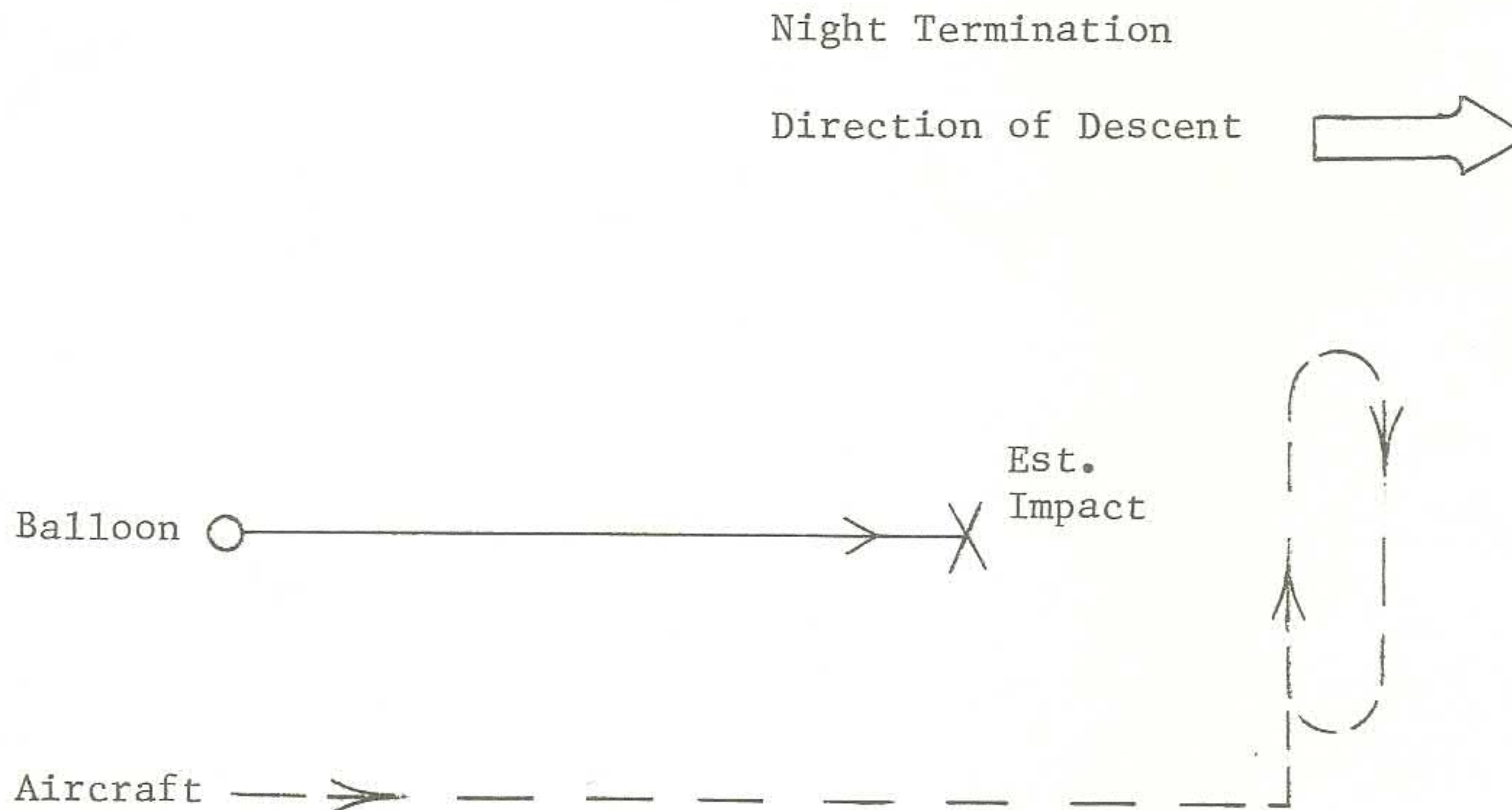
C. Get into position for termination. The best position is approximately 10 miles from the balloon with the aircraft between the balloon and the sun.

V. During Termination

A. During the day, watch the balloon for successful termination. If possible, keep visual contact with the balloon and the scientific package. This is very important in the event of radio failure on the scientific package. Circle the package keeping the parachute in approximately the 9:00 position on the aircraft (just ahead of the left wing tip).

B. Report descent altitudes as required by the FAA. Keep yourself oriented while circling the parachute, and when the package approaches your altitude, descend with it to keep it in visual contact to impact. Record the position of impact.

C. At night, listen for loss of altitude on balloon to indicate successful termination. Then fly the pattern shown in diagram below. When the scientific package reaches 20,000 feet, circle the parachute, record your position throughout descent until impact. After impact, fly over the package and record the position. The next day, come back and look for it.



VI. Recovery

A. If a recovery vehicle is in the area, direct it to the package by use of two way radio.

B. If a recovery vehicle is not available, land at the nearest airport where rental vehicles are available. Then drive to the package. At times, you may have to draw a map of the area to be able to drive to the package, also, at other times, it can be so complicated that you may have to use a walkie-talkie and direct the route from the air.

C. Each recovery is different. After arriving at the package, the best way to get it out can be determined. A package that can be taken apart with components weighing less than 100 lbs., makes for a relatively easy recovery in nearly all circumstances.

VII. Security

A. After termination, get to the package as soon as possible to insure safety of the package.

B. In the event that the package cannot be taken out right away and the package needs to be guarded, contact the sheriff of the county. He should be able to provide someone that can be hired to guard the package.

E8. INFLATION TABLES AND METERING PROCEDURES

Tables

Abbreviated inflation tables follow for helium and hydrogen. These tables are based on the assumption that the container is a steel cylinder with a length "several" times its diameter. The compressibility of the gas has been included. Analysis has shown that linear interpolation between tabulated values is adequate. Note that the pressure is in absolute units, thus a barometer is needed to correct the "gage" reading. However, large errors in barometric pressure are not significant if the lowest container pressure is six or more times the normal atmospheric pressure (i.e., 90 psi).

Metering

To meter a given amount of lift:

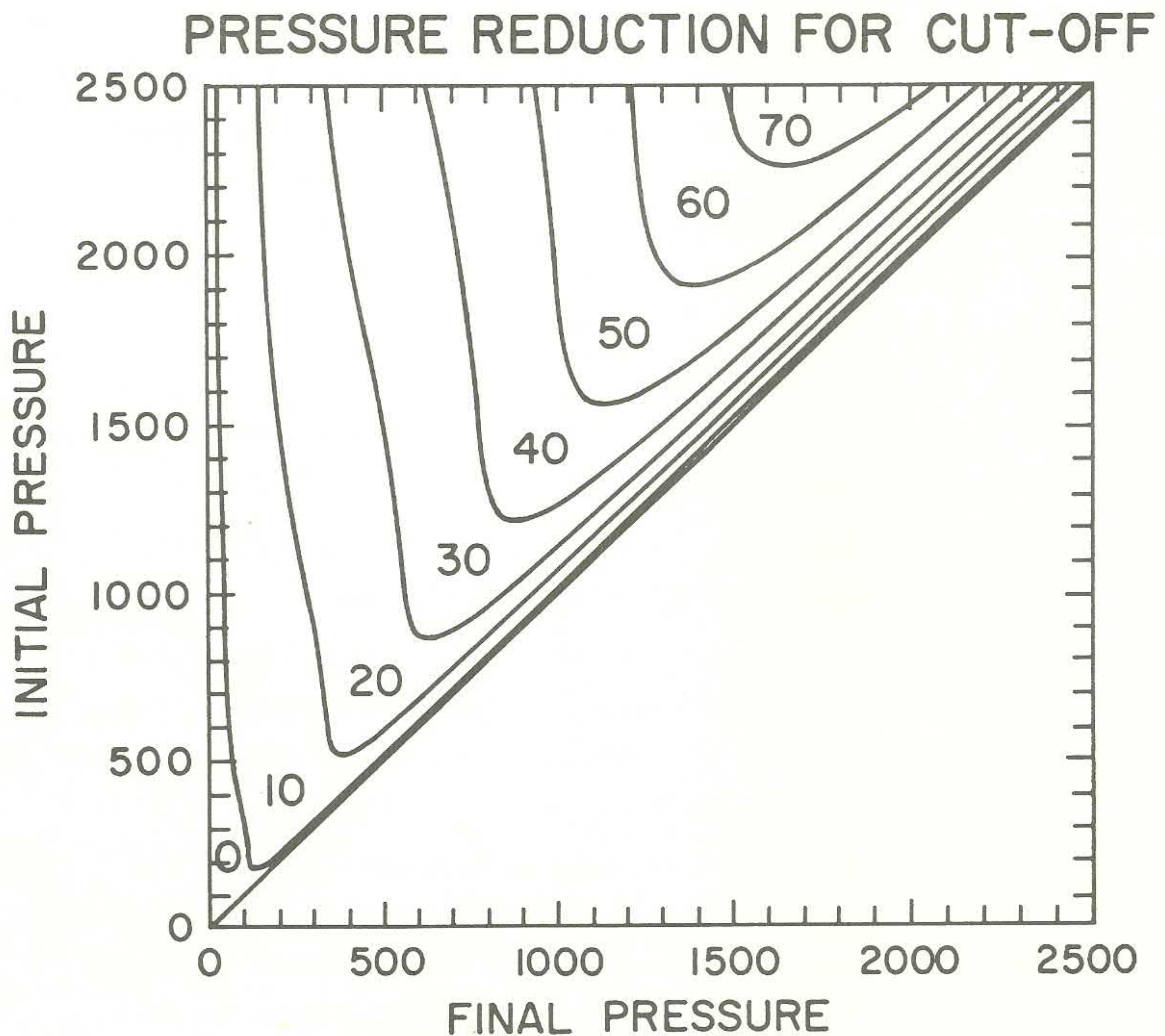
1. Measure initial gas temperature and pressure.
 - a. These are best measured in tanks that are shaded from the sun and when the temperature is stable. Use a recently calibrated pressure gauge which has been carefully protected from shock. Lightly tap the gauge before taking a reading.
 - b. Temperature should be the average of several etched-glass laboratory thermometers located at the extremes of the collection of cylinders, e.g., at the two ends of a trailer. Thermometers should be shaded.
 - c. Temperature and pressure may be measured at a convenient time within a few hours in advance of the flight, but care must be taken to ensure that no gas is subsequently lost through leaks. In case of doubt the temperature and pressure should be read again immediately prior to inflation.
2. Read the water volume of each cylinder. Find a total water volume.
 - a. The number of cylinder to be used must be estimated. The more cylinders used the faster inflation will take place.

- b. Normally only the number of cylinders are used which will fill the balloon ending with a cylinder pressure of 5 to 10 psig. Never completely "empty" any cylinder, a positive, internal pressure is required to prevent contamination.
 - c. The best accuracy will be obtained if all cylinders but one are simultaneously drained to 5 to 10 psig. The last cylinder is then used alone, ending at some intermediate pressure as outlined in step 5.
3. Enter the table (for the gas being used) and find the initial lift per cubic foot of water volume. Multiple the initial total lift in the cylinders.
 - a. It is important to note that the pressures in the tables are in absolute pressure units. Since most pressure measuring instruments are in gauge pressure units, it is necessary to know the barometric pressure. Large errors in the barometric pressure will be insignificant if the minimum pressure in the cylinders is 90 psig or more.
4. Subtract the lift to be metered, i.e., the gross inflation, to obtain the residual lift in the cylinders. Divide the residual lift by the total water volume to obtain the residual unit lift.
5. Enter the same table with the residual unit lift and find the residual pressure at the residual cylinder temperature.
 - a. The residual temperature is difficult to find. The actual temperature in the cylinder will be reduced because of rapid gas expansion. If the initial temperature was read just prior to launch it can be used.
 - b. In lieu of the correct residual temperature a procedure has been developed to modify the residual pressure. At the intersection of the initial pressure and final pressure values in the following graph a pressure decrement is determined.
The residual pressure found above is reduced by this pressure decrement and becomes the final pressure for the

cylinder or cylinders.

c. Again note that the pressure in the table is absolute and must be reduced by the barometric pressure to find the usual gauge pressure.

6. This procedure for metering a given amount of lift should be followed as a check, even if a weigh-off method is used such as the Huch Clutch.



E9. GENERAL SAFETY PRECAUTIONS - HIGH PRESSURE GAS

Introduction

The General Safety Precautions listed herein concern themselves only with the field handling and use of a high pressure, (up to 2400 psig) inert, compressed gas such as helium. If other chemically active gases are used, such as hydrogen or ammonia, additional precautions, not addressed here, must be observed.* Suppliers of compressed gases may be requested to furnish special instructions.

General Precautions

1. Always identify contents of gas cylinders.
2. Thoroughly inspect cylinders and associated equipment for shipping damage. If damage is suspected, don't use.
3. Never allow cylinders to drop during handling. Store in horizontal position.
4. Store cylinders away from open flame, high heat, and out of direct sunlight.
5. Remove cylinder protective cap(s) only when immediate use is intended.
6. Open and close valves by hand, never by wrench or lever. Open slowly to avoid surges in attached components.
7. When using a manifold system:
 - a. Ensure all mating joints are clean.
 - b. Thread carefully, tighten, and check for leaks.
 - c. Close valves and bleed system before attempting repairs or if it is to be left unattended.
8. Never tamper with safety devices or valves.
9. Leave a residual pressure of at least 5 psig, over atmospheric, in used cylinders.

Reference. Instructions and safety precautions for all common compressed gases may be found in the following publication:

*Compressed Gas Association, Inc., 1966, Handbook of Compressed Gases. Reinhold Publishing Corp., New York, NY 398 pp.

10. Ensure valves are closed, and safety caps are replaced on used cylinders.
11. Tag damaged, defective cylinders or inoperative valves for supplier's information.

GRADE A HELIUM

GAS PRESSURE (PSIA)	GAS TEMPERATURE (DEG. F.)					GAS LIFT (LBS. LIFT PER CU. FT. OF WATER VOLUME)					GRADE A HELIUM				
	0	10	20	30	40	50	60	70	80	90	100	110			
14.7	07437	07279	07128	06983	06844	06710	06582	06459	06340	06225	06115	06008			
50	25262	24727	24214	23723	23251	22798	22363	21944	21540	21152	20777	20415			
100	50431	49265	48344	47364	46425	45522	44654	43819	43014	42240	41493	40772			
150	75508	73915	72389	70925	69521	68171	66873	65625	64423	63264	62148	61070			
200	10049	98377	96350	94406	92539	90746	89022	87363	85765	84226	82742	81310			
250	12539	12275	12023	11781	11548	11325	11110	10903	10704	10513	10328	10149			
300	15019	14704	14402	14113	13835	13568	13311	13064	12826	12596	12375	12162			
350	17491	17125	16774	16437	16114	15803	15505	15217	14940	14674	14416	14168			
400	19953	19536	19137	18753	18385	18032	17692	17364	17049	16745	16452	16169			
450	22407	21940	21492	21062	20650	20253	19872	19505	19151	18810	18482	18164			
500	24852	24335	23839	23363	22905	22467	22045	21638	21247	20869	20505	20154			
550	27283	26721	26178	25656	25155	24674	24211	23766	23336	22923	22523	22138			
600	29716	29099	28509	27942	27397	26874	26371	25886	25420	24970	24536	24117			
650	32135	31469	30832	30220	29632	29067	28524	28001	27497	26999	26513	26039			
700	34545	33821	33147	32490	31860	31253	30670	30109	29568	29045	28533	28033			
750	36947	36185	35454	34753	34080	33433	32810	32210	31632	31075	30533	30019			
800	39340	38530	37754	36999	36273	35585	34933	34305	33691	33099	32527	31975			
850	41725	40868	40045	39257	38499	37770	37069	36394	35744	35116	34511	33926			
900	44102	43197	42330	41497	40693	39929	39189	38477	37790	37128	36493	35872			
950	46470	45519	44605	43731	42890	42081	41303	40553	39831	39134	38462	37812			
1000	48830	47832	46875	45957	45075	44226	43410	42623	41865	41134	40429	39747			
1050	51182	50138	49137	48176	47253	46365	45510	44687	43894	43129	42390	41677			
1100	53526	52435	51391	50388	49424	48497	47605	46745	45917	45118	44345	43591			
1150	55862	54726	53629	52572	51558	50582	49653	48767	47914	47097	46307	45520			
1200	58199	57009	55877	54790	53746	52741	51774	50843	49945	49078	48242	47434			
1250	60509	59284	58109	56980	55896	54854	53850	52882	51950	51050	50182	49343			
1300	62821	61551	60323	59140	57996	56899	55849	54846	53879	52947	52049	51182			
1350	65125	63811	62550	61340	60170	59039	57949	56904	55902	54943	54017	53125			
1400	67421	66063	64761	63510	62300	61132	60009	58926	57881	56873	55900	54963			
1450	69709	68308	66963	65673	64432	63239	62089	60982	59914	58883	57890	56937			
1500	71990	70545	69159	67829	66550	65319	64134	62992	61891	60833	59812	58827			
1550	74263	72775	71348	69978	68661	67393	66173	64996	63862	62767	61710	60693			
1600	76528	74998	73530	72120	70765	69461	68205	66995	65828	64701	63613	62564			
1650	78786	77213	75705	74256	72863	71523	70232	68985	67780	66620	65511	64440			
1700	81036	79421	77872	76385	74955	73578	72253	70975	69743	68553	67404	66293			
1750	83278	81622	80033	78507	77040	75628	74268	72956	71692	70471	69292	68151			
1800	85514	83816	82187	80623	79119	77671	76277	74932	73635	72384	71174	70005			
1850	87741	86003	84334	82732	81191	79709	78280	76902	75574	74291	73052	71854			
1900	89963	88182	86509	84915	83387	81919	80502	79137	77819	76544	75312	74121			
1950	92175	90355	88689	87081	85538	84055	82632	81266	79944	78667	77432	76241			
2000	94381	92521	90816	89211	87671	86193	84768	83395	82064	80783	79542	78351			
2050	96580	94679	92979	91371	89831	88355	86932	85560	84238	82965	81732	80541			
2100	98771	96821	95177	93574	92036	90563	89144	87777	86454	85175	83942	82751			
2150	100956	98975	97377	95774	94236	92763	91344	89977	88654	87375	86142	84951			
2200	10313	10111	99517	97916	96386	94919	93502	92137	90814	89535	88302	87111			
2250	10530	10325	10167	10007	98536	97063	95644	94277	92954	91675	90442	89251			
2300	10747	10537	10377	10217	10056	99063	97619	96232	94894	93605	92362	91171			
2350	10962	10749	10587	10427	10266	10113	99677	98287	96944	95655	94412	93221			
2400	11177	10960	10797	10637	10476	10323	10177	10037	99024	97725	96472	95271			
2450	11391	11171	11007	10847	10686	10533	10387	10246	10109	99800	98547	97346			
2500	11605	11380	11215	11055	10894	10741	10593	10450	10311	10176	10045	99194			

PURE HYDROGEN

GAS PRESSURE (PSIA)	GAS TEMPERATURE (DEG. F)					GAS LIFT (LBS. LIFT PER CU. FT. OF WATER VOLUME)					GAS TEMPERATURE (DEG. F)				
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
14.7	08028	07857	07694	07538	07388	07244	07106	06972	06844	06720	06591	06466	06342	06219	06097
15.0	08033	07862	07700	07544	07394	07250	07112	06978	06850	06726	06597	06472	06348	06225	06103
15.5	08038	07867	07705	07549	07400	07256	07118	06984	06856	06732	06603	06478	06354	06231	06109
16.0	08043	07872	07710	07554	07405	07261	07123	06989	06861	06737	06608	06483	06359	06236	06114
16.5	08048	07877	07715	07559	07410	07266	07128	06994	06866	06742	06613	06488	06364	06241	06119
17.0	08053	07882	07720	07564	07415	07271	07133	06999	06871	06747	06618	06493	06369	06246	06124
17.5	08058	07887	07725	07569	07420	07276	07138	07004	06876	06752	06623	06498	06374	06251	06129
18.0	08063	07892	07730	07574	07425	07281	07143	07009	06881	06757	06628	06503	06379	06256	06134
18.5	08068	07897	07735	07579	07430	07286	07148	07014	06886	06762	06633	06508	06384	06261	06139
19.0	08073	07902	07740	07584	07435	07291	07153	07019	06891	06767	06638	06513	06389	06266	06144
19.5	08078	07907	07745	07589	07440	07296	07158	07024	06896	06772	06643	06518	06394	06271	06149
20.0	08083	07912	07750	07594	07445	07301	07163	07029	06901	06777	06648	06523	06399	06276	06154
20.5	08088	07917	07755	07599	07450	07306	07168	07034	06906	06782	06653	06528	06404	06281	06159
21.0	08093	07922	07760	07604	07455	07311	07173	07039	06911	06787	06658	06533	06409	06286	06164
21.5	08098	07927	07765	07609	07460	07316	07178	07044	06916	06792	06663	06538	06414	06291	06169
22.0	08103	07932	07770	07614	07465	07321	07183	07049	06921	06797	06668	06543	06419	06296	06174
22.5	08108	07937	07775	07619	07470	07326	07188	07054	06926	06802	06673	06548	06424	06301	06179
23.0	08113	07942	07780	07624	07475	07331	07193	07059	06931	06807	06678	06553	06429	06306	06184
23.5	08118	07947	07785	07629	07480	07336	07198	07064	06936	06812	06683	06558	06434	06311	06189
24.0	08123	07952	07790	07634	07485	07341	07203	07069	06941	06817	06688	06563	06439	06316	06194
24.5	08128	07957	07795	07639	07490	07346	07208	07074	06946	06822	06693	06568	06444	06321	06199
25.0	08133	07962	07800	07644	07495	07351	07213	07079	06951	06827	06698	06573	06449	06326	06204
25.5	08138	07967	07805	07649	07500	07356	07218	07084	06956	06832	06703	06578	06454	06331	06209
26.0	08143	07972	07810	07654	07505	07361	07223	07089	06961	06837	06708	06583	06459	06336	06214
26.5	08148	07977	07815	07659	07510	07366	07228	07094	06966	06842	06713	06588	06464	06341	06219
27.0	08153	07982	07820	07664	07515	07371	07233	07099	06971	06847	06718	06593	06469	06346	06224
27.5	08158	07987	07825	07669	07520	07376	07238	07104	06976	06852	06723	06598	06474	06351	06229
28.0	08163	07992	07830	07674	07525	07381	07243	07109	06981	06857	06728	06603	06479	06356	06234
28.5	08168	07997	07835	07679	07530	07386	07248	07114	06986	06862	06733	06608	06484	06361	06239
29.0	08173	07999	07837	07681	07532	07388	07250	07116	06988	06864	06735	06610	06486	06363	06241
29.5	08178	08004	07842	07686	07537	07393	07255	07121	06993	06869	06740	06615	06491	06368	06246
30.0	08183	08009	07847	07691	07542	07398	07260	07126	06998	06874	06745	06620	06496	06373	06251
30.5	08188	08014	07852	07696	07547	07403	07265	07131	06999	06875	06746	06621	06497	06374	06252
31.0	08193	08019	07857	07701	07552	07408	07270	07136	07004	06880	06751	06626	06502	06379	06257
31.5	08198	08024	07862	07706	07557	07413	07275	07141	07009	06885	06756	06631	06507	06384	06262
32.0	08203	08029	07867	07711	07562	07418	07280	07146	07014	06890	06761	06636	06512	06389	06267
32.5	08208	08034	07872	07716	07567	07423	07285	07151	07019	06895	06766	06641	06517	06394	06272
33.0	08213	08039	07877	07721	07572	07428	07290	07156	07024	06900	06771	06646	06522	06399	06277
33.5	08218	08044	07882	07726	07577	07433	07295	07161	07029	06905	06776	06651	06527	06404	06282
34.0	08223	08049	07887	07731	07582	07438	07300	07166	07034	06910	06781	06656	06532	06409	06287
34.5	08228	08054	07892	07736	07587	07443	07305	07171	07039	06915	06786	06661	06537	06414	06292
35.0	08233	08059	07897	07741	07592	07448	07310	07176	07044	06920	06791	06666	06542	06419	06297
35.5	08238	08064	07902	07746	07597	07453	07315	07181	07049	06925	06796	06671	06547	06424	06302
36.0	08243	08069	07907	07751	07602	07458	07320	07186	07054	06930	06801	06676	06552	06429	06307
36.5	08248	08074	07912	07756	07607	07463	07325	07191	07059	06935	06806	06681	06557	06434	06312
37.0	08253	08079	07917	07761	07612	07468	07330	07196	07064	06940	06811	06686	06562	06439	06317
37.5	08258	08084	07922	07766	07617	07473	07335	07201	07069	06945	06816	06691	06567	06444	06322
38.0	08263	08089	07927	07771	07622	07478	07340	07206	07074	06950	06821	06696	06572	06449	06327
38.5	08268	08094	07932	07776	07627	07483	07345	07211	07079	06955	06826	06701	06577	06454	06332
39.0	08273	08099	07937	07781	07632	07488	07350	07216	07084	06960	06831	06706	06582	06459	06337
39.5	08278	08104	07942	07786	07637	07493	07355	07221	07089	06965	06836	06711	06587	06464	06342
40.0	08283	08109	07947	07791	07642	07498	07360	07226	07094	06970	06841	06716	06592	06469	06347
40.5	08288	08114	07952	07796	07647	07503	07365	07231	07100	06976	06847	06722	06598	06475	06353
41.0	08293	08119	07957	07801	07652	07508	07370	07236	07104	06980	06851	06726	06602	06479	06357
41.5	08298	08124	07962	07806	07657	07513	07375	07241	07110	06986	06857	06732	06608	06485	06363
42.0	08303	08129	07967	07811	07662	07518	07380	07246	07114	06990	06861	06736	06612	06489	06367
42.5	08308	08134	07972	07816	07667	07523	07385	07251	07120	06996	06867	06742	06618	06495	06373
43.0	08313	08139	07977	07821	07672	07528	07390	07256	07124	07000	06871	06746	06622	06499	06377
43.5	08318	08144	07982	07826	07677	07533	07395	07261	07130	07006	06877	06752	06628	06505	06383
44.0	08323	08149	07987	07831	07682	07538	07400	07266	07134	07010	06881	06756	06632	06509	06387
44.5	08328	08154	07992	07836	07687	07543	07405	07271	07140	07016	06887	06762	06638	06515	06393
45.0	08333	08159	07997	07841	07692	07548	07410	07276	07144	07020	06891	06766	06642	06519	06397
45.5	08338	08164	08002	07846	07697	07553	07415	07281	07150	07026	06897	06772	06648	06525	06403
46.0	08343	08169	08007	07851	07702	07558	07420	07286	07154	07030	06901	06776	06652	06529	06407
46.5	08348	08174	08012	07856	07707	07563	07425	07291	07160	07036	06907	06782	06658	06535	06413
47.0	08353	08179	08017	07861	07712	07568	07430	07296	07164	07040	06911	06786	06662	06539	06417
47.5	08358	08184	08022	07866	07717	07573	07435	07301	07170	07046	06917	06792	06668	06545	06423
48.0	08363	08189	08027	07871	07722	07578	07440	07306	07174	07050	06921	06796	06672	06549	06427
48.5	08368	08194	08032	07876	07727	07583	07445	07311	07180	07056	06927	06802	06678	06555	06433
49.0	08373	08199	08037	07881	07732	07588	07450	07316	07184	07060	06931	06806	06682	06559	06437
49.5	08378	08204	08042	07886	07737	07593	07455	07321	07190	07066	06937	06812	06688	06565	06443
50.0	08383	08209	08047	07891	07742	07598	07460	07326	07194	07070	06941	06816	06692	06569	06447
50.5	08388	08214	08052	07896	07747	07603	07465	07331	07200						

Appendix F. BALLOON GROUPS

F1. Commercial

F2. Government

F1. ' COMMERCIAL ORGANIZATIONS

- a. Each of the below listed firms have a capability to design, construct, and supply balloons and associated hardware and equipment, extending to a fully self-contained flight kit. In addition, most retain qualified operations personnel who can be made available as consultants, as a launch director, or as a full flight crew.

Raven Industries, Inc.
Box 1007
Sioux Falls, South Dakota 57101

The Sheldahl Co.
Highway 3, North
Northfield, Minnesota 55057

Winzen Research Inc.
Fleming Field
South St. Paul, MN 55075

- b. The following firms are established suppliers of rubber or neoprene balloons, in sizes ranging from small "PIBALS" to 3000 gram-rated balloons. Larger sizes may be specially made.

KAYSAM Corporation of America
27 Kentucky Avenue
Paterson, New Jersey 07503

Weather Measures Corporation
P.O. Box 41257
Sacramento, CA 95841

F2. GOVERNMENT AGENCIES

The following government organizations are involved in ballooning operations and will provide consultation on small ballooning problems. These agencies will normally require reimbursement for travel and personnel expenses incurred by outside activity, such as providing the services of a launch director.

U.S. Air Force Geophysical Research Laboratories*
L.G. Hanscom Field
Bedford, Massachusetts 01730

National Center for Atmospheric Research
National Scientific Balloon Facility
Box 1175
Palestine, Texas 75801

Office of Naval Research
Physics Branch, Code 421
800 North Quincy Street
Arlington, Virginia 22217

*Formerly U.S. Air Force Cambridge Research Laboratories